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Environmental Response Design and Implementation Guidance

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United States Department of Energy
Office of Environmental Policy and Guidance (EH-413)
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National Environmental Training Office (NETO)

National Environmental Training Office
A United States Department of Energy Training Center of Excellence

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1. Introduction

1.1 Objective

Environmental cleanup activities at DOE sites are generally conducted under the authority of one of two environmental programs: the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). While there are distinct differences between these two programs and how they are implemented, the ultimate goal -- protecting human health and the environment -- and many of the recognized steps in the processes, are very similar (See Exhibit 1). The concepts presented in this document apply to the cleanup process, regardless under which regulatory framework the cleanup is taking place.

The purpose of this guidance is to assist DOE project managers to efficiently and effectively manage design and implementation of environmental restoration projects.

The objective of this guidance, issued by the Department of Energys (DOEs) Office of Environmental Policy and Assistance (EH-413) and Office of Program Integration (EM-43), is to assist the DOE project manager in efficiently and effectively managing the design and implementation phases of environmental response projects conducted as corrective actions under RCRA, or remedial actions under CERCLA. The concepts addressed and the level at which they are addressed have been selected to be of use to anyone with decision making responsibility for environmental response efforts as well as to technical and support staff reporting to the project manager.

1.2 Background

The guidance provided herein is drawn from the collective experience of cognizant managers working on both public and private lead sites since the inception of environmental programs in the United States. The guidance is also drawn from the inherent flexibilities provided in existing environmental programs. The lessons learned through the evolution of environmental response programs have been distilled into a framework that fosters streamlining and encourages continued quality improvement through innovation. It is the intent that this document will convey both the substance and the rationale for the framework as it is structured currently without tying it to detailed processes or procedures. In this way, the reader is encouraged to embrace the philosophy and principles behind streamlining initiatives with freedom to develop new and innovative procedures that will continue the improvement process. No attempt is made to show how this approach fits within any specific regulatory program. The reader looking for a cookbook approach will be disappointed, as will the design engineer interested in a tutorial on the design process. Conversely, readers with engineering design skills and experience will be introduced to concepts and tools that will help them apply those skills more efficiently to environmental response challenges.

The Principles of Environmental Restoration apply throughout the remediation process, regardless of regulatory framework. Although the RCRA Corrective Action and CERCLA Remedial Action programs use different names for the same stages of the environmental restoration process, there are a number of common requirements between the two programs. Because of these commonalities, detailed in Exhibit 1, the principles apply to the cleanup process regardless of which regulatory framework the cleanup is taking place under.

Exhibit 1: Common Elements in RCRA and CERCLA

RCRA	CERCLA	COMMON REQUIREMENTS
RFA	PA/SI	Identify releases and need for further investigation
RFI	RI	Characterizes the nature and extent of contaminant releases
CMS	FS	Identification, evaluation, and screening of remedial alternatives
Statement of Basis	Proposed Plan	Identification and public notice of the preferred alternative
PERMIT MODIFICATION	**ROD**	**REMEDY SELECTION**
CMD	RD	Development of detailed plans for selected remedy
CMI	RA	Construction, testing, and implementation of selected remedy
Closure/Post-Closure	Completion	Construction completed and post-construction plans in place
Closure/Post-Closure	Closure	Specified cleanup levels reached and remedial activities complete

The National Environmental Training Office (NETO) offers specific training for environmental response design and implementation in a course entitled Principles for Accelerating Remedial Design and Implementation.[1] This guidance provides much of the material available in the course as well as additional reference materials and examples to further illustrate how the principles are applied. Neither

[1]For information on this training course, contact NETO at 803-725-0814, or at www.em.doe.gov/neto.

the course nor the guidance are designed as prerequisites for the other. Rather, each stands alone, individually reinforcing the lessons each would teach.

1.3 Organization

The guidance begins with a discussion of the principles of environmental restoration, their origin, and their application to the various phases of an environmental response. The subsequent sections address planning and scoping activities, design, implementation, and post-construction considerations. Throughout the guidance, reference is made to how activities are impacted by the principles of environmental restoration and a graphic is provided to illustrate the specific interfaces among the principles for those activities. The guidance includes an appended listing of references and related materials such as training courses that will further assist the reader in the conduct of environmental response. A glossary is also provided to assist the reader with the acronyms and terms of art that have become so commonplace in the environmental response lexicon.

The Principles of Environmental Restoration

Principle 1:	Defining and maintaining focus on the objective is critical.
Principle 2:	Early identification of probable means of achieving the objective is possible, prudent, and necessary.
Principle 3:	Uncertainties are inherent and must be managed.
Principle 4:	Early, open communication and consensual decision making by stakeholders is essential.

It is important to note that in the broader sense, design begins when the problem statement is first devised for a site and the project manager begins to consider the types of responses that may be appropriate. For the purposes of this manual, design refers to the quantitative development of plans and specifications. That should not be taken as tacit acceptance of a more limited definition of design. Rather, it is used to focus this guidance on a very specific set of post-decision document design activities.

1.4 Assumptions

This guidance is premised on a set of assumptions about the user, the point in the environmental response activity at which the user has arrived, and expectations for what the user will take away from the guidance. These assumptions are as follows:

The user:

- Is a DOE project manager, decision maker, design engineer, or line manager responsible in some way for the success of environmental response design and/or implementation;

- Has training and/or experience in engineering design or construction management; and
- Is conversant in environmental response program fundamentals such as regulatory framework and programmatic mission.

At this point in the program:

- Site investigation activities have been concluded and a response technology has been selected;
- A decision document (e.g., a record of decision or statement of basis) has been or is about to be issued;
- Decision makers are working together through agency representatives to implement the decision; and
- Options remain open with respect to how supporting goods and services will be procured.

2. Principles of Environmental Restoration

2.1 Introduction

The current approach to environmental restoration was first codified in the National Contingency Plan (NCP), and later described in guidance developed for the RCRA corrective action program. By design, the materials provide for flexibility in how restoration is ultimately accomplished. However, early on, activities became very process oriented and ensuing environmental response projects emerged as both expensive and time consuming. Soon, it became apparent that adequate resources were not available to apply the extensive process to all sites thought to be contaminated.

Faced with increasing demands on diminishing resources and growing criticism from a public and Congress anxious to see results, practitioners began to look for ways to a accelerate the clean up process through the development and implementation of various streamlining initiatives. For example, EPA and DOD developed and implemented the *Superfund Accelerated Cleanup Model (SACM)* and the *Presumptive Remedy Engineering Evaluation/Cost Analysis (PREECA)*, respectively. DOE, building on tenets of the *Observational Method*, a geotechnical engineering strategy applied to cleanup, and EPAs *Data Quality Objective (DQO)* process, developed and applied the *Streamlined Approach for Environmental Restoration (SAFER)* at a number of its sites. A 1997 EPA analysis[2] of these efforts found that all were effective in reducing the cost and schedule of environmental cleanups. As DOE began to look more closely at these initiatives, as well as the individual histories of its own acceleration approaches, four basic principles emerged. These principles are:

- Principle 1: Defining and maintaining focus on the objective is critical.
- Principle 2: Early identification of probable means of achieving the objective is possible, prudent, and necessary.
- Principle 3: Uncertainties are inherent and must be managed.
- Principle 4: Early, open communication and consensual decision making by stakeholders is essential.

The streamlining principles embodied in this document were first articulated in an environmental restoration training course cosponsored by the EPA and DOE.[3] At the time, the primary focus was on application of the principles to pre-decision document activities, i.e., scoping, data collection, and selection of a response action. Experience with applying the principles and moving more sites to the post-decision document phases has made it apparent that the principles are equally applicable to the design, implementation, and post-construction activities, and can form the basis for achieving response objectives in less time and at lower cost. Accordingly, they form the framework for this guidance, and understanding the principles and their origins is imperative. Ultimately, the reader is encouraged to use an understanding of the principles to develop approaches to restoration without being tied to traditional processes. In this way, the evolution and re-engineering of environmental response will continue with the infusion of new ideas.

2.2 Define Objective and Maintain Focus On It

2.2.1 General

More than any of the other three, this principle appears to be a simple statement of the obvious, and to a certain extent, it is. Unfortunately, as environmental remediation has become more process oriented, it has drifted away from adherence to this principle. Site managers have become preoccupied with seemingly endless investigations generating copious amounts of data which in truth may not advance a decision makers ability to identify the basic problem and design its solution.

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[2] Streamlining Initiatives: Impact on Federal Facilities Cleanup Process. OSWER 9272.0-12. December 1997.

[3] For information on the Principles of Environmental Restoration training course contact the National Environmental Training Office.

Often, reports and procedural steps have been designated as milestones to which activities have been focused irrespective of their contribution to the ultimate objective of restoring the environment to an agreed upon level. For example at some sites, risk assessments have been performed on pre-response conditions even after the decision to conduct a removal action has been made. In this case, unless the risk assessment is being used to help establish the cleanup level, this effort results in considerable use of resources with no value added because the decision to take action, and the action itself, have already been decided. The unfortunate outcome of this loss of focus on the primary objective often is to conduct projects without clearly stated objectives, resulting in unfocused activities incurring unnecessary costs.

An example of a site-wide problem statement:

> *Cesium-137 is found above 80 pci/g in the top six inches of soil across an area of five square feet or more or in a total volume of greater than 100 cubic feet.*

For a specific waste management unit, an example problem statement would be:

> *The presence of sufficient hazardous metals in cesium-137 containing sludges to qualify residues as D007 wastes.*

2.2.2 Pre-Decision Document Application

In the pre-decision document phase, this principle can be restated as follows: Clear, concise and accurate problem identification and definition is critical. A problem is defined as a site condition posing a real or potential unacceptable risk, or a condition that decision makers determine requires a response. Conditions that do not require a response are not a problem. At the same time, a risk may not actually exist (e.g., contaminant is present but no viable exposure pathway exists), yet the perception of risk may motivate decision makers to respond. Therefore, the condition creating the perception of risk constitutes a problem.

Key elements of any problem statement include the affected media (e.g., soil, ground water, sediments, surface water, etc.), the contaminants of concern and their concentration, the volumes of media affected, and regulatory or other drivers. Ideally, a threshold concentration can be identified such that when contaminant levels are found above that concentration, the existence of a problem is confirmed. If the threshold is defined in terms of risk levels or qualitative statements, it may be difficult to confirm with certainty that a problem exists. If the condition can not be adequately confirmed to establish whether a problem exists, there is a data need. However, data needs themselves are not problems. Indeed, operable units, release sites, or waste area group classifications are not problems in and of themselves. They are merely locations where problems may exist if conditions are such that a response is required.

Prior to issuance of a Decision Document, focusing on the objective can be stated as clear, concise, and accurate definition of the problem. This later shifts to defining the response action, and ultimately a definition of the end state.

As illustrated in the example (highlight box), it is best if problem statements are kept simple and explicit, emphasizing why a condition is a problem. To that end, they must include criteria (either quantitative or qualitative) that necessitate a response(s) when met. If such criteria can not be identified, it is generally not possible to tell if a problem exists.[4]

2.2.3 Post-Decision Document Application

Once a response is formalized in a decision document, the focus shifts from identifying the problem to defining the response. During design, this first principle translates to the need for a clear, concise statement of the objective. During implementation, the principle focuses on developing a clear, concise statement of what constitutes construction complete and applies a means of measuring progress towards that end point. Ultimately, during the post-construction phase, the focus is on meeting the response objective (e.g., remove all ground water contaminants above a threshold concentration) as measured by performance monitoring.

2.2.4 Summary

In essence, the principle consistently preserves the concept of maintaining attention on the target, but its application to individual phases of activity allows for sharper focus on the next decision that must be made to move forward. As illustrated in Exhibit 2, the translation through the phases of environmental response coincides with the specific objective defined for those phases. In the pre-decision document phase, the primary objective is to determine if there is a problem. During design, the primary objective is to develop the best means for meeting response objectives as defined in and constrained by the decision document to address the problem. During implementation, the primary objective is to complete the necessary activities (e.g., construction of engineering systems, establishment of construction controls, installation of monitoring systems) to achieve the response objective.

Exhibit 2: Translating Focus on the Objective Throughout the Process

Principle	Pre-Decision Document	Response Design and Implementation	Post-Construction Completion or Closure
Defining and maintaining focus on objective is critical (What needs to be done?)	Clear, concise statement of the problem	Develop clear, concise statement of restoration objective(s) and performance measurements to demonstrate response completion	Document construction is complete and/or desired end state has been reached

[4] Refer to *Expediting Cleanup Through Problem Identification and Definition, DOE/EH-413-9904, May 1999* for additional information not contained in this guidance.

Construction completion may or may not result in immediate closure depending on the response selected. If operations or long-term care are a part of the response, there will be post-construction activities that must be performed to meet the specific objective of correcting conditions highlighted in the problem statement as unacceptable. If there are not post-construction activities, site closure has been achieved when construction is complete.

2.3 Early Identification of Probable Means of Achieving the Objective

2.3.1 General

While the first principle is focused on *what* is to be accomplished, the second is focused on *how* it is to be accomplished. Early versions of the environmental restoration program established a process that utilized sequential activities wherein initial efforts involved data collection to characterize a site, followed by analysis of all possible technologies to select the best response for resolving the problem. Two decades of experience however, indicate that for many common scenarios, there are only a few (often only one) technologies that will likely surface as the remedy of choice. Indeed, recognizing circumstances when a single technology is inevitably the best selection, the EPA has developed presumptive remedies which can be selected without extensive analysis when site characteristics so warrant. The second principle recognizes that with the accumulated knowledge from previous efforts, it is possible to focus efforts early, and in so doing, reduce time and cost associated with evaluating alternatives that will never be selected.

2.3.2 Pre-Decision Document Application

In the pre-decision document phase, the second principle focuses on early identification of the probable response technology for the site. By identifying the most probable technology or technologies early on, it is possible to collect important data during site characterization efforts that will assist in both the selection and design activities. This early winnowing may eliminate the need for supplemental investigations while reducing costs associated with collecting data for technologies that will not be deployed.

Prior to issuance of the Decision Document, the focus of Principle 2 is early identification of the likely response action. This later transitions into early identification of the likely design basis.

If the field of potential technologies can be narrowed significantly, the problem statement derived under the first principle is extended to form a decision rule. As illustrated in the highlight box, the problem statement itself becomes the if portion of the rule, while the probable technology is inserted for the then portion.

The second principle is applied in the pre-decision document phase by identifying a hierarchy of probable technologies that are most likely to be the response of choice. In addition to simply selecting technologies that experience suggests would be effective at a site, the hierarchy may be developed as a result of guidance on presumptive remedies,[5] using the plug-in Record of Decision approach,[6] or reviewing decision documents for sites with similar conditions. Once likely technologies are identified, they are prioritized on the basis of their potential effectiveness, cost, and implementability based on available knowledge. Each technology is characterized by key design parameters or fatal flaws that will ultimately determine the feasibility of applying that technology at a given site. A fatal flaw is a condition or parameter value which impacts the implementability or efficacy of a response to the degree that the response will not meet the remedial action objective, or is no longer preferred over other options. The data needed to determine if a fatal flaw exists and what an optimum design would look like then become the focus of field investigations. Remaining site characterization efforts are one element of this focus since the site characteristics of interest are those that will determine the selection and design of the response.

> An example of a decision rule formulation for a site-wide problem statement:
>
> *IF Cesium 137 is found above 80 pci/g of soil in any 100 square foot area 6 inches deep (measured using standard site protocols) and the total estimated volume of contaminated soil is less than 100 cubic yards, THEN excavate the hot spot, remove the exhumed soils to storage area Z, and manage the material as low-level waste.*

As data are collected, if it is determined that a fatal flaw exists for the preferred technology (i.e., the technology will not work, or the applicable design is such that the technology would no longer be the first choice), that technology is dropped or reprioritized in favor of the next most desirable technology. As noted previously, data not associated with selection or design of the response may not be needed. As a consequence, once the preferred technologies are identified, work plans should be reviewed with an eye to eliminating unnecessary activities.[7]

2.3.3 Post-Decision Document Application

Once the decision document is issued, the response action is identified. By definition, there no longer are alternative technologies to be evaluated (e.g., capping versus excavation of wastes). However, there are few, if any, standard designs for response technologies. Moreover, the decision document rarely contains sufficient detail to constrain the design of the selected technology. As a

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[5] *Presumptive Remedies: Policies and Procedures*, EPA Directive 9355.0-47FS, September 1993.

[6] *The Plug-In Approach: A Generic Strategy to Expediting Cleanup*, DOE/EH-413-9903, May 1999.

[7] Refer to *Expediting Cleanup Through Identification of Likely Response Actions,* DOE/EH-413-9902, May 1999, for additional information not contained in this guidance.

consequence, there are an array of possible designs for the selected response, including innovations that could yield savings in time and cost, as well as possibly enhance the technologys effectiveness. Therefore, at this stage, the second principle translates to early identification of the likely design basis (e.g., need to handle runoff from the 100 year storm event or maximum allowable rate of infiltration).

By choice, decision documents do not contain anywhere near the information required to select implementation contractors and authorize them to proceed. The design phase is needed to translate the decision document into a set of designs and specifications sufficient to instruct the implementation contractors on how to proceed. Accordingly, during implementation, it is incumbent on the contractor to develop work plans and procedures early in the process as well as the configuration of any post-construction requirements. The earlier the configuration of long-term care provisions, the more likely a smooth transition from construction into the long-term care phase.

2.3.4 Summary

The second principle promotes early identification of the best means for accomplishing response objectives as articulated according to the first principle. Prior to the issuance of the decision document, the focus is on identifying the proper technology for the response. As illustrated in Exhibit 3, with issuance of the decision document, the emphasis shifts to identifying the best design for that technology
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Exhibit 3: Translating Likely Response Throughout the Process

Principle	Pre-Decision Document	Response Design and Implementation	Post-Construction Completion or Closure
Early identification of probable means of achieving objective (How will it be done?)	Early identification of likely response actions	Review response components, review and approve likely design basis, and review and approve contract delivery strategy	Identify post-construction completion requirements for long-term response actions or post-closure requirements for long-term stewardship, including contingency or corrective action measures

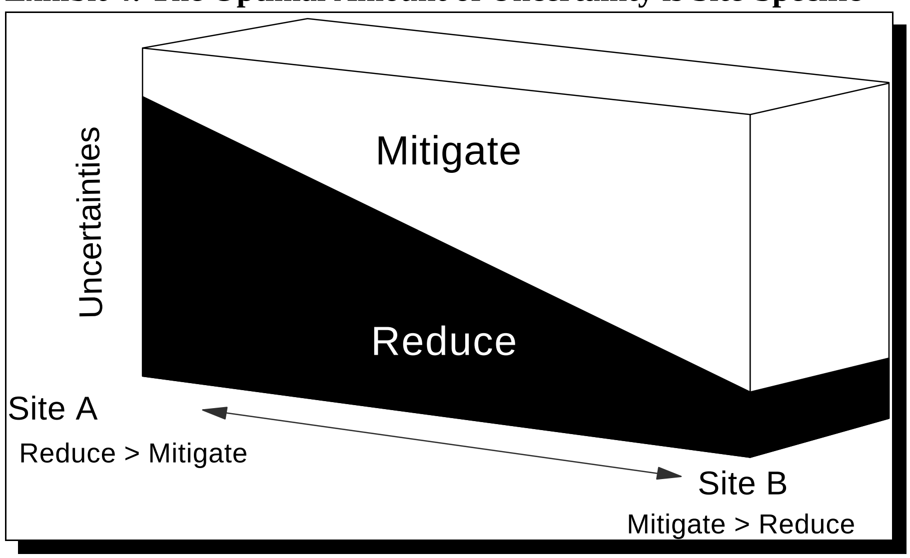
2.4 Uncertainty Management

2.4.1 General

Since much of the contamination at sites occurs in ground water and subsurface rock and soils, it is difficult to characterize the nature and extent of residual contamination. Soils and aquifer materials are generally heterogeneous. Changes in texture and composition create uncertainty regarding the presence, condition, fate, and transport of hazardous substances. As a consequence, uncertainty is inherent in environmental response and can never be completely eliminated. Site characterization, design, and implementation efforts can quickly become complex and time consuming if one seeks to remove all uncertainty. Therefore, it becomes necessary to manage uncertainty by weighing the costs and impacts of reducing unknowns through data collection now, against the costs of having to implement contingency plans to address potential issues if the uncertain conditions are realized later.

The consequences of residual uncertainties can vary greatly. If a response action is sufficiently robust, it may be unaffected by deviations in site conditions, thus removing the need to narrow the uncertainty surrounding those conditions. In other cases, alternate conditions may prove fatal to a design and necessitate formulation of contingency plans so that a response action need not be halted when and if those conditions are encountered. As illustrated in Exhibit 4, the optimal amount of uncertainty will be site-specific. At some sites (e.g, an area with surface soil contaminated with dioxin), strenuous efforts to reduce uncertainty in advance may pay off in a much more efficient cleanup. This is illustrated by Site A. Conversely, at other sites (e.g., a heterogeneous landfill), prior characterization may have little benefit, and the challenge is to manage uncertainty during remediation. This is illustrated by Site B. At most sites, both approaches are used to some degree. Optimization means striking the right balance between the two.

Exhibit 4: The Optimal Amount of Uncertainty is Site-Specific



2.4.2 Pre-Decision Document Application

In the pre-decision document phase, key uncertainties exist for conditions or parameters which will affect the selection of a response technology. If there is a threshold value beyond which an alternate technology would be necessary, then the consequences of not knowing the actual value can be significant. These key parameters often are one and the same as fatal flaws and key design parameters identified under the second principle. During the pre-decision activities, the analyst determines the range of values that may be encountered for each uncertain condition or parameter. If the range does not exceed the critical threshold, the work can proceed to selection and design including contingencies as a tool to manage the uncertainty. However, if the range of probable values spans the threshold value, the analyst must weigh the merits of narrowing the range by collecting additional data to those of preparing contingencies that would be implemented to counteract the impact of the deviation at the time that it was encountered. In essence, the contingency plan or a robust design raise the threshold value to ensure it falls outside the range of remaining uncertainty. For example, if the volume of contaminated soil to be excavated is uncertain and may be greater than available storage/disposal capacity, the options would be to drill more boreholes to better constrain the range of probable values or identify alternate capacity that would accept the overage.

Uncertainties are inherent and will need to be managed throughout the duration of the environmental response.

The uncertainty matrix (described later in Section 4.2.3) is a tool designed to assist in managing uncertainty by organizing information and facilitating consideration of alternate management strategies. In preparing the matrix, the analyst must continually ask the question: What if the true value of a parameter is either extreme of the range of possible values, rather than the assumed value? In this way he/she can determine the effects of potential deviations to see if those possibilities can be tolerated or must be counteracted.[8]

2.4.3 Post-Decision Document Application

Once the decision document is issued, it is both costly and time consuming to perform additional data collection prior to implementation. Presumably though, the decision makers have elected to manage residual uncertainty through contingency planning or robust designs (i.e., the residual uncertainties are sufficiently bounded that they will not invalidate the response selection.) At this point, the major impact from uncertainties relates to design considerations, not technology selection, i.e., the potential deviation will not cause a dramatic failure with the technology selected and/or the contingency.

The design engineer is forced to estimate values for the purpose of setting the design basis. Plans must be in place to deal with likely deviations from the estimated values. Plans could include selecting a design value that is sufficiently

[8]Refer to *Uncertainty Management: Expediting Cleanup Through Contingency Planning, DOE/EH/(CERCLA)- 002, February 1997* for additional information not contained in this guidance.

robust to not be materially affected by the range of possible conditions, or devising contingencies that would be invoked when the unanticipated conditions are encountered during implementation. In the rare instance where costs and consequences are severe, additional data may be sought to reduce the uncertainty further.

Uncertainties that will be encountered will generally relate to site conditions and technology performance. The design has been based on expected (estimated) conditions and performance. Contingencies are selected on the basis of the range of possible deviations from those expectations (estimates).

When contingencies are developed as the means of managing uncertainties, a monitoring system must be devised to alert decision makers when conditions have crossed relevant thresholds indicating the need to implement the contingency. Accordingly, during the implementation phase, responsibility must be assigned to conduct the monitoring and to evaluate the results. Ideally, the monitoring will provide unequivocal evidence in sufficient time to minimize work stoppage.

To the extent that a response incorporates post-construction activities (e.g., maintenance of caps, operating pump and treat systems), there will be a need for continual monitoring and a plan for what will be done if the monitoring indicates that objectives are not being met. When construction is complete, the paramount uncertainty is whether the problem is resolved or progress in being made towards resolution. If there is no question that the response is complete (e.g., all contaminated soil was located and removed), there should be no need for monitoring or contingencies. However, many responses do not provide such definitive results (e.g., capping or other barriers). For those, questions remain as to whether all contamination has been located and mitigated. Hence, there is a need for post-construction monitoring for many sites. Commensurate with that need is the need for a plan of action should the monitoring data confirm failure or inadequate progress.

2.4.4 Summary

Uncertainties in the value, or state, of parameters or conditions affecting response selection, design, and performance exist, and will persist through the duration of environmental restoration projects. Project managers must manage uncertainty either by reducing it through data collection or counteracting impacts with contingencies. As illustrated in Exhibit 5, the focus of uncertainty evaluation shifts from factors affecting the selection of a response during the pre-decision document phase to those affecting the design and implementation of a response during the post-decision document phase.

Exhibit 5: Uncertainty Management throughout the Process

Principle	Pre-Decision Document	Response Design and Implementation	Post-Construction Completion or Closure
Uncertainties are inherent and must be managed	Evaluate effects uncertainty could have on response selection	Evaluate potential effects of uncertainties on response design; design monitoring to detect deviations; design contingency measures (as needed)	Monitor to provide early warning that long-term response will fail to meet objectives or that engineered/institutional systems continue to function as designed

2.5 Early, Open Communication and Consensual Decision Making

2.5.1 General

Historic antagonism between and among the various stakeholders at a site arises from different perceptions about uncertainties and different levels of comfort dealing with risk management. One of the keys to bringing the perceptions of these parties closer together is to foster frequent, early, and open communication. Everyone needs to know the facts so that they can participate in the decision making process in a meaningful way. Without open communications, one or more parties may become fearful that they have been denied critical information or have not been heard and, therefore, may be reluctant to accept the defined problems and preferred solutions.

Frequent, early, and open communication is critical to all phases of the environmental restoration process.

DOE and EPA are promoting the concept of a core team approach is one in which an empowered representatives of each of the decision making agencies works cooperatively together to move projects forward. Members of a core team act as co-project managers and consequently, share equal responsibility and ownership for the technical aspects of the project. All information is shared openly and all decisions require a consensus. Frequent public briefings are encouraged to keep the public apprized of anticipated decisions in hopes that timely input will be obtained and public concerns effectively accommodated.

Ideally, the core team can establish a consensual platform to work from by agreeing on primary objectives and boundaries early in the process. At that point, they can openly discuss methods to be applied and the meaning of likely results. If all parties can agree on approaches, there is less likelihood that there will be conflict over the results. It is the latter type of conflict which leads to rework and redundancies that could have been avoided. It is important for the core team to document agreements as they are reached so that progress can be maintained even if individual members of the team change over time.

Although working cooperatively, regulatory agencies retain their respective authorities. Ultimately remedial decisions, whether they are provided in the form of a decision document, permit, or enforcement order, continue to be the sole province of the regulatory authority. The intent is to accelerate the process by having mutually acceptable information and work plans submitted early on, rather than being arrived at through a trial and error process of repeated submittals by the regulated party. In this spirit, the core team concept can apply equally to RCRA corrective action measures or CERCLA projects without losing the required regulatory roles of the respective parties.

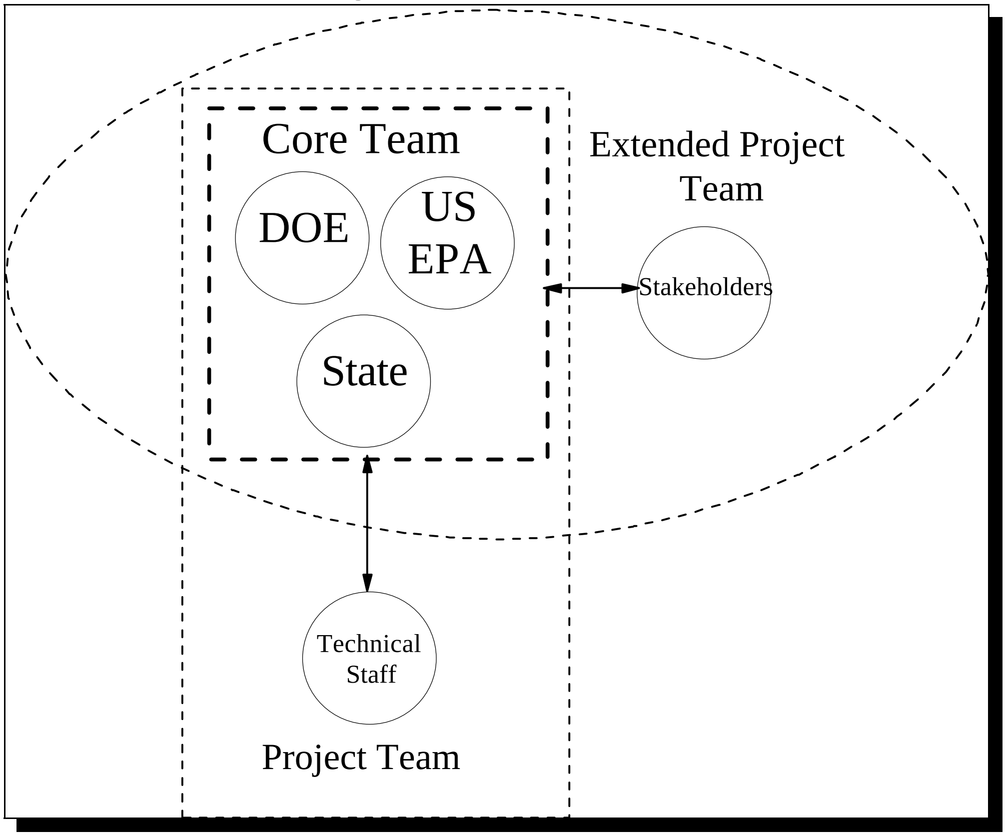
2.5.2 Pre-Decision Document Role

In the pre-decision document phase, core team involvement includes development of the problem statement, selection of the preferred response action, and approval of the uncertainty management plan. Activities to support the core team in making decisions are performed by the expanded project team, which includes contractors and support personnel.

While these functions have always been required in the environmental response process, the approach is quite different if based on the core team concept. Under a core team approach, for example, the focus of developing reports is simply to document the decisions agreed to by the core team. DOE and its stakeholders agree to strategies and plans before DOE performs the work and writes the reports. Because DOE and its contractors have a good sense of what the regulators expect, the core team approach reduces the possibility that their products will be found unacceptable by stakeholders and that DOE will be required to conduct significant rework. In contrast, DOE has often developed its cleanup strategies and performed work separately and then used reports to communicate the rationale for its preferred approach to stakeholders (including regulators). If stakeholders did not agree with DOEs approach or rationale, the disagreement often resulted in confrontations, deteriorating relationships between DOE and its stakeholders, and costly rework for DOE.

In other words, the core team approach extends the involvement beyond DOE personnel so that stakeholders can be more engaged in the scoping, direction, objectives and results of the project. The focus is on joint progress in which all parties take ownership. The paradigm involves sharing control of the technical work as well as responsibility for moving forward. Importantly, all stakeholders develop and understand the uncertainty management plan so that there is less likelihood that different perceptions of residual uncertainties will deadlock activities later in the project. The organization of the core team, including the project and extended project teams, is illustrated in Exhibit 6.

Exhibit 6: Core Team Organization



2.5.3 Post-Decision Document Role

When the decision document is issued, the core teams immediate task is to review and interpret the document itself. As discussed in Section 3.2, decision documents are often interpreted differently by different parties. In order to minimize conflict and keep activities focused, it is important to reach a consensus on what is intended by the decision document. Reaching consensus is the task of the core team which then must convey to the design team a clear indication of what the design team must do and under what constraints they are working.

Ultimately, the core team will need to approve the design package and the uncertainty management plan (contingencies) developed by the design team. There will be significant flexibility in how the core team chooses to review designs and contingencies. Many core teams will request frequent briefings on status accompanied by approval of any major decisions along the way. Other core teams will delegate design to the project manager and approve only the final package. Either approach can work as long as the core team is kept advised of decisions as they are made and exercises its option to question or influence decisions of concern. The intent is to have all parties on board so that no significant design effort is spent pursuing options the core team will not support.

During implementation, core team efforts will be split between communication and evaluation. Communication activities will relate to keeping the public informed of progress. Evaluation will focus on reviewing the results of performance measurement and deviation monitoring to determine how the work is progressing and when contingencies should be implemented. As part of the evaluation process, the core team approves use of significant contingencies prior to implementation. If implementing the contingencies will result in a significant change from the original design the core team should notify and explain to the public the decision to proceed with implementation of the contingencies.

After implementation, the core team should have a defined role in conducting agreed upon reviews (e.g., five year review). If the response includes post-construction activities, those activities will be the subject of a continuing oversight role with the attendant goals of determining progress and evaluating the need to implement contingencies if the response does not appear to be meeting project objectives.

As illustrated in Exhibit 7, the involvement of the core team is important throughout the life of an environmental response. However, the frequency and level of interactions will diminish first with issuance of the decision document and then again with completion of construction.

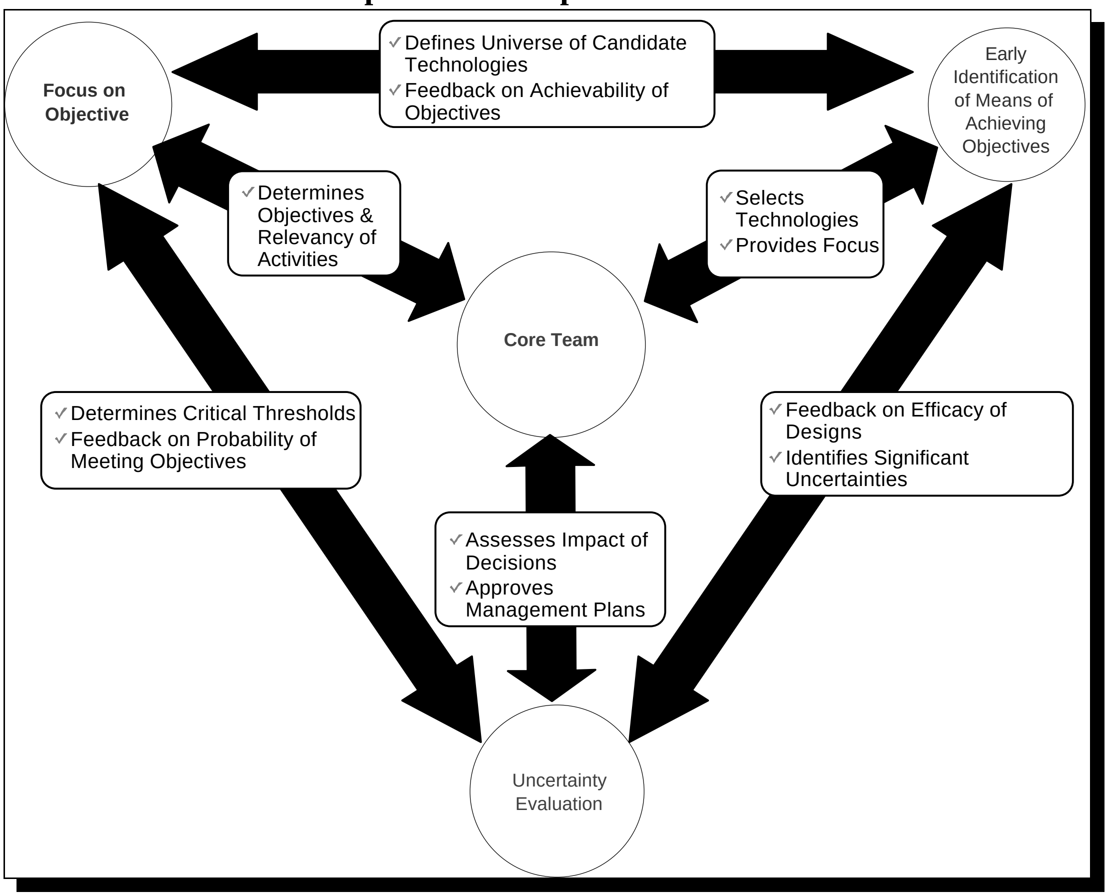
Exhibit 7: Core Team throughout the Environmental Response Process

Principle	Pre-Decision Document	Response Design and Implementation	Post-Construction Completion or Closure
Early open communication and consensual decision making by stakeholders	Prepare problem statement, select response action, and accept level of residual uncertainties	Develop consensus interpretation of a decision document; define/agree on objectives; interpret performance measurements and monitoring data; approve designs, residual uncertainty management plans, and implementation of contingencies	Conduct 5-year reviews; review monitoring data and direct implementation of contingency or corrective action measures as necessary

2.6 Inter-Relationship of Principles

The four principles are highly interdependent with the core team playing a central role in their orchestration. Exhibit 8 illustrates this interdependence. The guidance provided herein has been developed using the principles as an underlying fabric to facilitate conduct of design and implementation in a timely and cost-effective manner. In that spirit, the project manager is encouraged to continually look for streamlining potential through application of the principles.

Exhibit 8: Interrelationship of the Principles of Environmental Restoration*



*Note: This graphic will be used periodically throughout this guidance to illustrate the applicability of the principles to the various design and implementation activities described. Although the principles (i.e., the circles) will remain constant in each graphic, the core team responsibilities (inner arrows) and how the principles interrelate to each other (outer arrows) will change.

3. Planning and Scoping Design and Implementation Activities

3.1 Introduction

The desire for acceleration of environmental response provides impetus for initiating design activities prior to issuance of the decision document. However, detailed design work prior to finalization of the decision document is at risk of being off target if all parties have not reached full agreement on a selected remedy. The conservative approach would be to defer all design activity until after issuance. However, from a practical standpoint, the need to evaluate cost and effectiveness as a part of response selection dictates at least preliminary design activities be accomplished to lend credibility to the selection process. Hence, the project manager is faced with a decision on when to start formal design efforts and how far to carry them before the decision document is issued. (It is recognized that the decision may be a foregone conclusion if the procurement strategy is based on selection of a design contractor after the decision document is issued.) The more obvious the likely response action (e.g., a presumptive remedy) and the less costly the design, the greater the merits of an early start. Conversely, if there are multiple alternatives capable of similar performance at comparable costs, the selection may be in doubt up to the issuance of the document. The point is, flexibility exists in the timing for initiating and completing design. The ability to focus on likely response actions and promote enhanced communications through an effective core team relationship are key to capitalizing on that flexibility.

> There often are significant differences of opinion as to what is *required* by a decision document and what is *allowed*. For example:
>
> Ground water will be restored to a quality level that retains its value as a potable water source could be interpreted to mean any of the following:
>
> - Restore the entire aquifer to drinking water standards;
> - Restore all off-site waters that contain drinking water wells to drinking water standards;
> - Treat all current water wells to drinking water standards at the point of extraction; or
> - Restore any of the three zones itemized above to background water quality.

While this guidance assumes a decision document has been issued at the time the design scoping begins, it applies to efforts initiated earlier in the process as well. To the extent that design predates issuance of the decision document, presumably there is at least a general understanding of the likely response sufficiently well developed to justify the early start. Those materials would then be the focus of initial efforts to interpret and understand the decision document as a starting point for design activities.

3.2 Interpretation of the Decision Document

3.2.1 Need for Interpretation

For many people, there is a perception that once the decision document is issued, all uncertainty has been removed and there is a clear path forward through design and implementation. As recognized in the third principle, this is simply not the case. Uncertainty is inherent throughout the environmental response process. Moreover, with streamlining initiatives, there is often a conscious effort to accelerate progress by spending fewer resources to reduce uncertainty and more to manage it through contingencies. Experience has shown, however, that not all parties will read and interpret the decision document the same way. For example, as shown in the highlight box, what is seemingly a simple statement in the Decision Document could lead to significant differences in interpretation. Each of these objectives would require considerably different response actions at substantially different costs. Some may not be possible with current technology. Clearly, the design engineer needs to know the intent of the statement in the decision document in order to avoid wasted effort. As a consequence, there is a need early on to derive a consensus interpretation of the decision document. This task is charged to the core team.

By intent, the decision document lacks the level of detail needed to allow a contractor to implement a response. The decision document is intended to provide a framework that will constrain the response without having performed all the work necessary to generate plans and specifications of sufficient detail to enable the implementation contractor to proceed. In essence, design is the activity necessary to input the required details to that framework.

The framework provided in the decision document includes both requirements and allowances. Requirements must be incorporated in the design (these may also include prohibitions of what is not allowed). Allowances are general areas that must be addressed, but there is flexibility as to how they are addressed. It is the allowances that provide the greatest opportunity for creative design to reduce cost and expedite the response.

Role of the Core Team

In order to help focus activities, members of the core team should develop consensus on the following types of questions:

- What is it that requires a response?
- What are we trying to achieve with the response (i.e., what are the performance objectives)?
- What are the components of the response?
- What are the requirements and allowances of the response?
- What criteria and standards must be met?
- Are there other conditions, such as permit requirements, that must be met?
- What is the desired end state (i.e., how do we know when we're done)?

3.2.2 Decision Document Requirements

In order to help focus interpretive activities, the core team should develop a consensus on the following key requirements that are contained in the decision document:

- Performance objectives;
- Response components;
- Criteria and standards;
- Additional requirements; and
- Performance measurements.

If the decision document is silent or incomplete with respect to these considerations, the core team must generate the missing information. For instance, the decision document may define the numerical criteria for the desired end state (e.g., soil contamination < 15 pci/g of X), but may not indicate how many measurements must be taken or how they are to be taken in order to determine if the response is complete. At the same time, the core team should refrain from over-constraining the response by introducing requirements where they are not needed. Requirements help focus the design effort (thereby reducing cost and time consumed in pursuing unproductive paths), but also reduce the opportunity for innovation and creativity that may improve overall performance while reducing life-cycle costs or implementation times. The core team needs to balance these factors to provide enough detail to ensure that the objectives are met to the satisfaction of all stakeholders without constructing unnecessary barriers to design optimization.

By clearly articulating a consensus interpretation, the core team provides unequivocal directions to the design team and minimizes the potential for future conflict arising from misunderstandings.

3.2.3 Decision Document Allowances

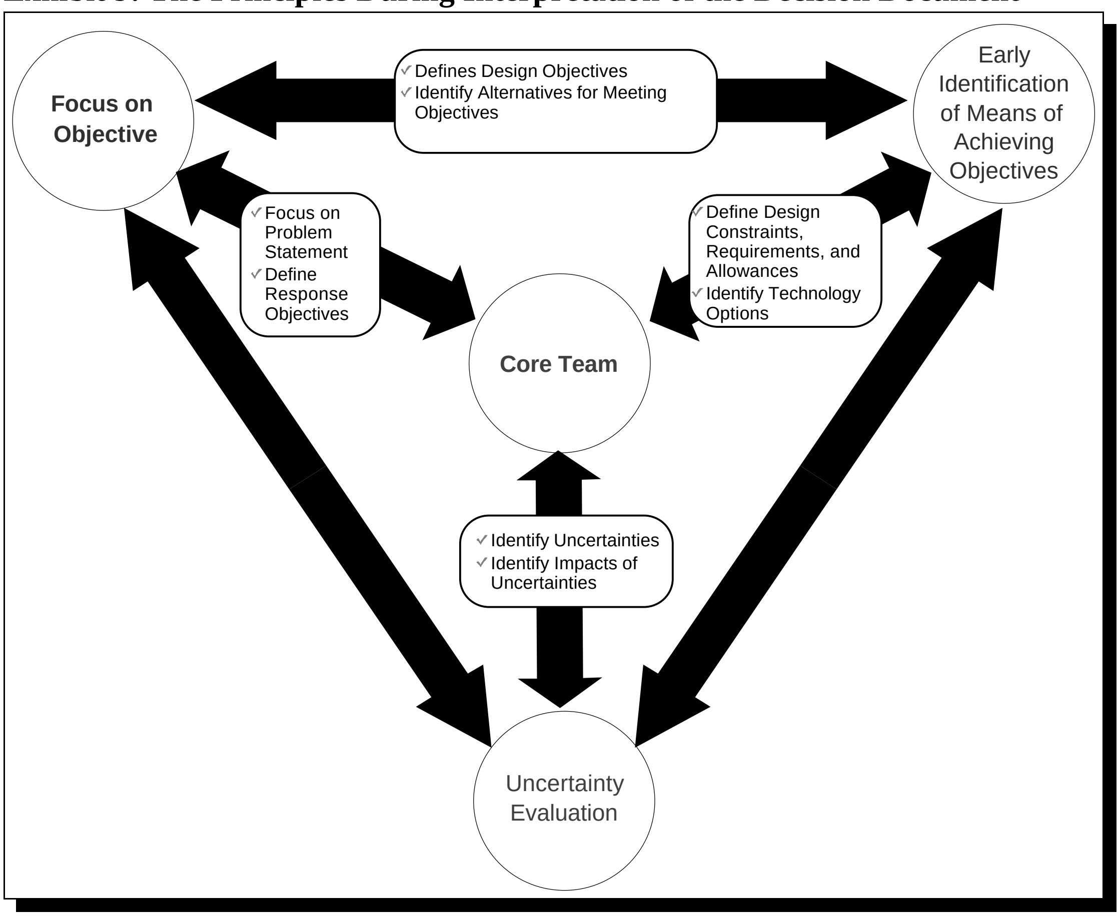
The value of a consensus interpretation stems from identifying allowances as well as requirements. The design team needs to know where they have flexibility to optimize and what the range of that flexibility is. For instance, if a soil vapor extraction system is required, are enhancements allowed? Is the design team free to consider surface seals, thermal enhancements or pneumatic fracturing to improve performance? Moreover, are there limits to which enhancement technologies can be considered or when they can be applied? Some decision documents are silent on such issues. Some dictate use of a specific option or provide rules for determining when an option may/must be applied. The nature and extent of prescription in the decision document defines the level of allowances available to the design team.

Environmental response is relatively new as a design activity. As a consequence, there are not nearly as many directly applicable design standards or codes as there are for more traditional activities. The lack of such standards forces the design engineer to carefully develop a design basis while fostering flexibility in the design process. The core team may choose to constrain some of that flexibility or may choose to highlight it to encourage creative design.

The core team should also help identify and highlight those areas where residual risk has been left for management by contingency. Decision documents often do not include a characterization of residual uncertainties intentionally left for management by contingency. Those residual risks must be considered during design and, when significant, must be associated with contingency plans capable of mitigating the impacts of deviations from expected conditions. Contingency plan technologies may well be preselected in the decision document, but depending on the probability of any given deviation, the level of requirements in a decision document relative to a contingency will vary greatly. Less probable eventualities are likely to be covered by less constrained contingency plans. These constitute areas of broad flexibility for the design engineer.

At this point, the core team has developed a consensus interpretation of what the decision document requires and where the design team is allowed flexibility. The project manager needs to identify what needs to be monitored and the best means for monitoring during the implementation phase. Refer to Appendix A for example decision document language and one interpretation of requirements and allowances included therein.   Exhibit 9 illustrates the interrelationship of the principles during interpretation of the decision document.

Exhibit 9: The Principles During Interpretation of the Decision Document



3.3 Monitoring Activities and Assumptions

3.3.1 Monitoring Needs

Throughout design and implementation, there will be a continuing need to be able to (1) measure performance of the remedy, and (2) determine if a deviation from expected conditions has occurred, triggering the need for a contingency. These two different objectives for monitoring have distinctly different orientations and may utilize quite different approaches during implementation. After construction, the two can become coincident depending on the nature of the response.

3.3.2 Performance Measurement

Performance measurement is a project management tool intended to help keep efforts on track and enable accurate progress reporting to all stakeholders. Performance measurement focuses on all activities up to the present time. In essence, it provides a glimpse of the road just traveled and the likely road that lies ahead. The objective is to accurately assess how much progress has been made towards the objective. As such, this metric must be based on the definition of the required end state so that progress is measured against the ultimate objective.

Preferably, the core team will identify parameters or conditions that can be observed as direct measures of real progress. Examples would include the volume of soil removed as a fraction of the estimated total inventory of contaminated soil, or the mass of contaminant removed from the estimated inventory using pump and treat or soil vapor extraction technologies. Since the actual inventory of contaminant and/or contaminated media is always uncertain and must be estimated, there is a need to review monitoring data during implementation to continually recalibrate the estimate.

Unfortunately, not all response actions are amenable to direct observations. For instance, containment or in situ technologies must be monitored through use of discrete monitoring points (wells) which can provide positive evidence of a failure, but only indications of success. There are no affordable technologies available to monitor performance directly across an entire plume. For response actions that offer a limited ability for measuring progress directly, technology performance constitutes an uncertainty and long-term monitoring requirements consist of both deviation monitoring and performance measurement combined.

Exhibit 10 presents some approaches to measuring performance for different response technologies.

Exhibit 10: Candidate Approaches to Performance Measurement for Common Technologies

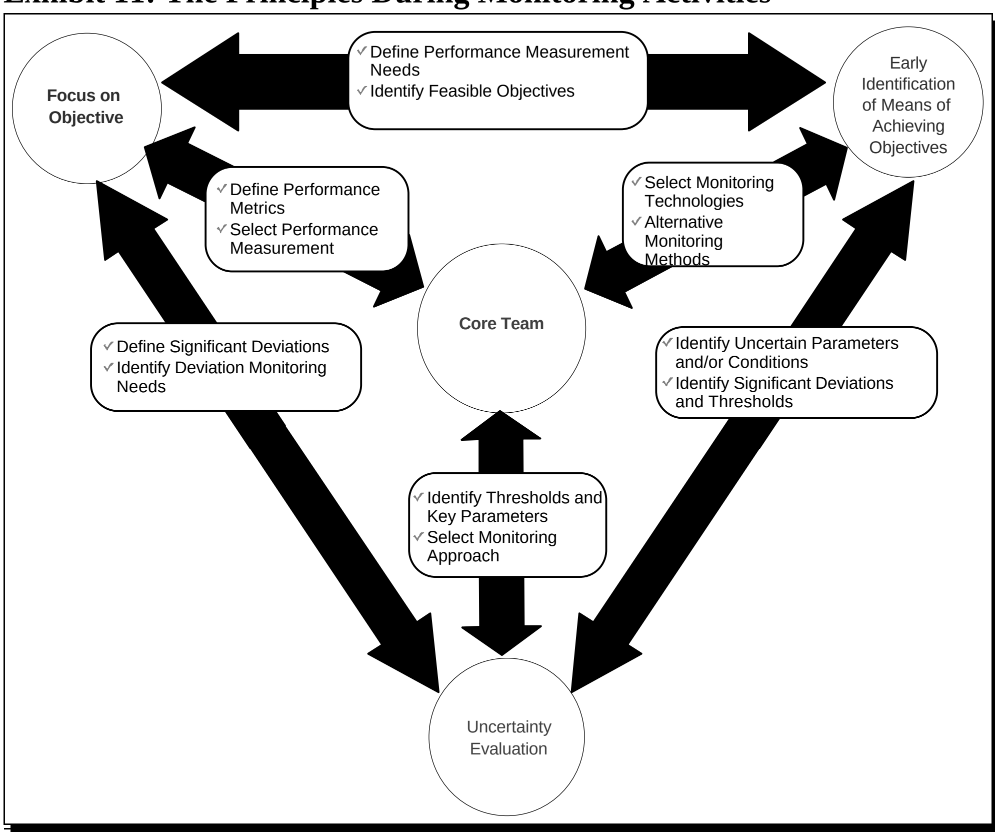
Technology	Construction	Post-Construction
Soil Excavation and Treatment	• Volume excavated as a percentage of estimated volume contaminated (if excavated material is basis of measurement, must account for expansion) • Excavated material or dig face analysis	• Confirmation sampling and analysis of dig face
Hydraulic Barriers	• Test barrier specimens to design specifications • Compare volume of materials used to estimates in design basis • Per cent completion	• Cross-barrier hydraulics • Long-term monitoring of down gradient water quality • Infiltration rate of cap • Moisture sensors for detection of leakage through caps
Permeable Barriers	• Test barrier specimens to design specifications • Compare volume of materials used to estimates in design basis • Per cent completion	• Long-term monitoring of down gradient water quality • Spot test with tracer injection
Pump and Treat	• Pump test wells • Piezometric head comparison before and after pumping • Shakedown testing of treatment module • Per cent completion	• Long-term monitoring of down gradient water quality • Piezometric head mapping during pumping • Effluent monitoring
Soil Vapor Extraction	• Pump test borings • Pressure head mapping during extraction • Per cent completion	• Pressure mapping across plume • Influent and effluent vapor monitoring • Rebound evaluation after shut down
Bioventing	• Pump test borings • Pressure head mapping during extraction • Per cent completion	• Pressure mapping across plume • Influent and effluent vapor monitoring • Rebound evaluation after shut down • Metabolic by-product monitoring
In-Situ Stabilization	• Compare volume of reagent applied to design basis • Sample and analyze of unstabilized border • Per cent completion	• Product testing for comparison to acceptance criteria • Penetrometer testing to determine shape and volume of stabilized mass • Confirmation of uncontaminated state of soil outside stabilized mass • Long-term ground water monitoring • Lysimeter collection of leachate
In-Situ Vitrification	• Sample and analysis of unstabilized border • Per cent completion • Temperature profile • Off-gas monitoring	• Product testing to acceptance criteria • Penetrometer testing to determine shape and volume of vitrified mass • Confirmation of uncontaminated state of soil outside vitrified mass • Long-term ground water monitoring • Lysimeter collection of leachate

3.3.3 Deviation Monitoring

In monitoring to determine when contingencies must be implemented, the focus is to the future. The intent is to provide as much advance warning as possible that conditions deviate from those assumed so that switching to the contingency incurs the least possible delay. Hence, the monitoring is devised to look at indicators which can be projected forward. Moreover, the condition being sought is unexpected, but possible. The condition must also be associated with a predicted or estimated value so that there is a metric against which to evaluate it. One example would be analyzing an excavation face and projecting the volume of contamination remaining to see if a maximum threshold volume is likely to be exceeded. A second example would be to characterize exhumed materials to detect trends in composition that foretell a change in chemistry that would impact the integrity of stabilized products. Deviation monitoring is scoped and specified as a part of the uncertainty management plan.

At this point, the core team and project manager have identified what needs to be addressed in the design effort. It is also necessary to develop a strategy for obtaining the necessary design and implementation services. Exhibit 11 highlights the interrelationship between the principles during deviation monitoring.

Exhibit 11: The Principles During Monitoring Activities



3.4 Project Delivery Strategy

3.4.1 Considerations

As a part of the remedial design and implementation, the core team must determine the degree to which decisions and related activities will be delegated and to what level that delegation will be made.

> **Role of the Core Team**
>
> The Core Team must determine which decisions and related activities will be conducted by the core team, and which are likely candidates for delegation. Activities best retained for the core team include:
>
> - Approval of the final design basis;
> - Approval of the uncertainty management plan, especially the nature of contingencies to be applied, if necessary; and
> - Evaluation of progress through interpretation of performance measurement results.
>
> Likely candidate activities for delegation include:
>
> - Interpretation of deviation monitoring;
> - Decisions to invoke a preselected contingency; and
> - Selection of the project delivery contract type.

Most core teams will want to retain authority to implement contingencies which represent a significant change or have a major impact. Other, less impactive contingency actions may be left to the discretion of the contractor managing the project. Selection of the project delivery contract type is generally left to the DOE project manager and should be concluded during scoping.

Once the nature of design and implementation activities has been defined in scoping activities, the project manager must select an optimum project delivery strategy, i.e., the plan for how work will be contracted and delivered. In many cases, there may be existing task order contracts in place which must be utilized, thus limiting the latitude in delivery options. In other cases, there may be an array of options. For the purposes of the guidance provided herein, the latter is assumed, recognizing that specific limitations will have to be assessed by the project manager on a case-by-case basis. If latitude is available, the project manager will need to review the contract options and select that which is best suited to the characteristics of the work scope. The project manager will also need to evaluate the work in terms of those activities best conducted independently, i.e., conduct of performance monitoring, versus having all work conducted by a single contractor.

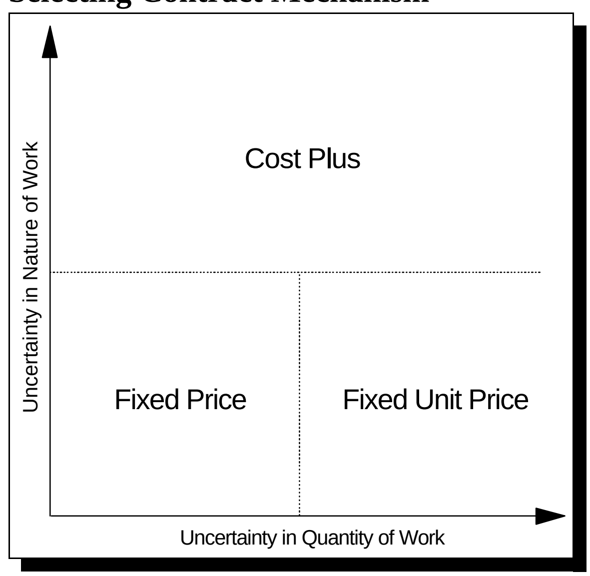
3.4.2 Contract Types

In selecting the proper project delivery strategy for the work scope, the project manager will need to determine the proper contract type, identify a procurement strategy, and develop a project delivery strategy.

There are three main types of contract vehicles that can be considered for each activity: 1) fixed price, 2) fixed unit price, and 3) cost plus. Fixed price contracts are awarded for a very specific scope of work, for a specified length of time and for a specific price. Fixed unit price contracts are very similar to fixed price contracts, except the scope of work does not have to be as explicitly determined prior to development of the contract. Cost plus contracts obligate the Government to pay the contractors actual costs incurred plus a fee. Once the contract type is determined, the specific contractor that will perform the work can be chosen through either a sole source or competitive bidding process. A detailed discussion of each of these contract types and contractor selection methods is provided in Appendix B: Contract Types.

The core team should initiate the procurement strategy as soon as it has developed a consensus interpretation of the decision document. The five main factors of a procurement strategy: complexity, certainty, scope, schedule, and interfaces, are discussed in detail in Appendix C: Factors Affecting Procurement Approach. While each procurement should be evaluated on its own merits, there are guidelines for selecting an optimum vehicle relevant to the nature of the response and the degree to which uncertainties exist. The relative desirability of each type of vehicle is illustrated in Exhibit 12. Generally, fixed price contracts provide the government with a high degree of cost and schedule protection. If there is a high degree of certainty in all aspects of the activity, except quantities of work to be performed, a fixed unit price contract would be appropriate. Activities that have little certainty associated with them and require a high degree of flexibility to continue would be best suited to some type of cost plus contracting. The critical need in any contract is that a reevaluation clause be established that allows the Department to reconsider the contracting approach for revising work not yet completed.

Exhibit 12: Impact of Uncertainty on Selecting Contract Mechanism



The project delivery strategy should be re-evaluated from time to time as the project proceeds to ensure that the strategy is modified to accommodate any changes in scope or approach that may arise as a result of design considerations. For example, discovery of multiple suppliers for what had been thought to be a proprietary technology, would enable a competitive bid rather than sole source procurement. The type of vehicle selected may also impact the level of detail required in the design package. For example, fixed price procurements usually require a greater level of specificity to prevent conflict over change orders during implementation. As a consequence, the core team and project manager will need to maintain direct access and frequent contact with procurement during scoping and design.

3.4.3 Incentivization

> The DOE project manager working with the contract specialist should ask the following types of questions when considering a procurement strategy:
>
> - How do the remaining uncertainties impact the selection of the procurement strategy?
> - Are there specific ways to incentivize this procurement?
> - How can the existing strategy be improved to ensure few change orders and resulting down time?

Whenever possible, selection of a contractor should be made on a competitive basis in lieu of sole source. Not only is it easier to move through the procurement process; if performed properly, it should provide the procuring party with the best combination of qualifications and price available. The key is to establish evaluation criteria in a manner that reflects life cycle costs for the procurement. Sole source procurements may be appropriate when proprietary technology is involved or when unique site conditions severely restrict the number of qualified firms.

There is no easy formula for determining an optimal contracting strategy. Each activity must be judged on its own merits considering the applicable factors as to whether it should be contracted out or not, the type of vehicle that should be imposed and the method for contractor selection. Fortunately, this does not have to be a difficult or involved process and, with an experienced contractor and project team, the answers to these questions will be intuitively obvious for most of the activities. Those activities for which the answers are not readily identifiable should be addressed early on to assure they do not negatively impact the project.

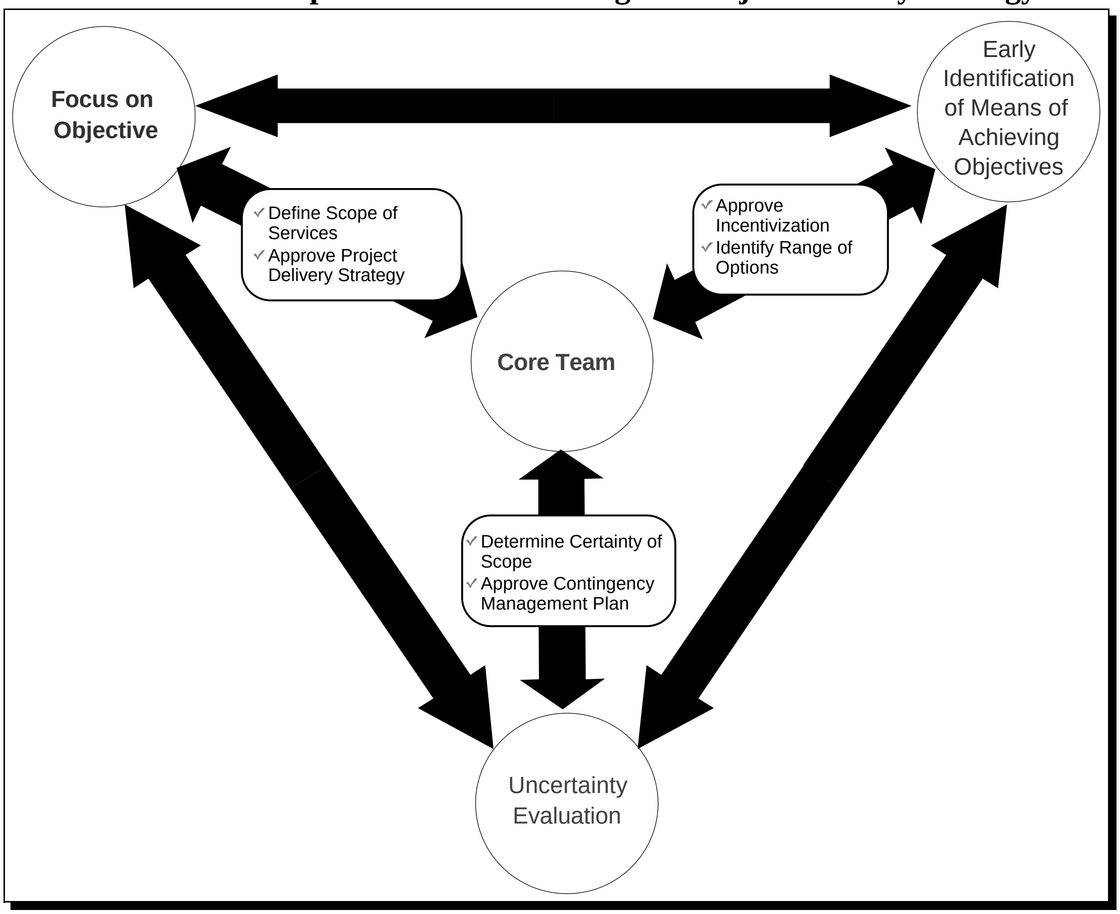
Whenever possible, incentives should be incorporated into the project delivery strategy. Incentives can be inserted into most contract types. Fixed price contracts are usually incentivized via the application of advanced completion bonuses and liquidated damages wherein the contractor either receives a fee certain for each day that a project is completed ahead of schedule (early completion bonus), or is penalized a like amount for each day over schedule (liquidated damages). Cost incentives may also be incorporated into contracts through application of value engineering principles. With this approach, the contractor proposes a less expensive method of accomplishing the same objective and, if accepted by the project manager, the contractor and the client share the savings according to a prearranged formula.

The cost plus type of contracts usually provide the greatest flexibility for performance incentives. Many times, most, if not all of the fee is determined by the contractors ability to meet predetermined criteria. Establishment of the criteria can be a powerful tool to incorporate time- and schedule-based incentives. However, it is important to tie incentives to performance goals over which the contractor truly has control. As an example, it may seem appropriate to try and ensure the quality of a written submittal by tying a milestone to getting the document approved by a specified date. Unfortunately, there may be many factors well beyond the quality of the document that affect when approval can be obtained. Ideally, incentives are tied directly to the objectives of the work (e.g. completion of designs, closure of an excavation, etc.) so that the contractor is motivated to make real progress rather than the appearance of progress. Examples of public and private sector incentive clauses and criteria that might be appropriate for environmental response contracts are included in Appendix D.

Scoping is concluded when the project manager has a clear, consensus-based definition of what is needed in the design package and a strategy for how to obtain it. At that point, detailed design can begin in earnest.

Exhibit 13 illustrates the interrelationship of the principles while determining a project delivery strategy.

Exhibit 13: The Principles When Establishing the Project Delivery Strategy



4. Designing the Response

4.1 Introduction

Simply put, environmental response design consists of the activities necessary to translate the information provided in a decision document into drawings and specifications of sufficient detail to enable a contractor to bid and successfully complete an installation that will meet all project objectives. This type of design work can differ significantly from more traditional engineering design for a number of reasons:

- There are significantly fewer consensus standards for environmental response designs;
- The composition of many of the materials that must be handled (e.g., contaminated soil, ground water, chemical sludge) can not be specified in the plans, but must be dealt with on an as-encountered basis;
- Much of the design is based on estimated values which may differ significantly from those actually encountered during implementation; and
- There is generally a heightened public awareness and concern for these projects that results in higher levels of scrutiny and greater need to clearly communicate progress.

All of these factors, but particularly the greater inherent uncertainty associated with environmental response, impact the way in which design proceeds.

Paramount in the design phase is the reliance on an iterative approach that requires the design engineer to make estimates and then evaluate the impact of potential deviations from those estimates. If the impacts are too great, the base assumption may be changed, or contingencies developed to counteract those impacts. The iterative approach lends itself to a culture of continuous quality improvement that fosters the search for new and improved ways to reduce the time and cost required to achieve restoration. The latter is particularly relevant today under the increasing demands for limited budget resources.

The iterative process begins with development of the design basis. It ends when the design engineer is comfortable that all uncertainties can be managed under the design or associated contingencies, and that based on estimated probabilities of occurrence, the balance between the two represents the minimum likely cost.

4.2 Design Basis

4.2.1 Setting the Basis

The design basis is a suite of characteristic values and conditions which define the properties that will affect how the response will perform. The design basis itself is NOT the design of the remedy. Rather, the design of the response reflects, and is based on, these values and conditions that are assumed to constitute the environmental setting in which the remedy must operate (see the highlight box).

> For example, if the selected response is for an impermeable cap, the design basis would define impermeability in terms of the following conditions and/or parameters:
>
> - Allowable infiltration rate (e.g., 10-7 cm/sec),
> - Area to be covered,
> - Run-on/run-off controls for specified storm intensity and frequency (e.g., manage surface flows from two one hundred year storm events in a one week period),
> - Constraints on cover vegetation (e.g., maximum allowable root depth and minimum evapotranspiration rate),
> - Slope of sides, and
> - Any provision for gas emissions (e.g., likely

In establishing the design basis, the engineer must identify the likely conditions or values for parameters that will prevail at the site. Hence, the designer must use an initial value recognizing that as implementation proceeds, it may become evident that the true value is different. When the difference can cause significant impacts, a contingency plan is needed to counteract those impacts. Therefore, in establishing a design basis, the engineer also initiates the next phase of uncertainty management: development of contingency plans to manage deviations from the assumed design basis.

During response selection, the focus of uncertainty management was on those conditions/parameters that would affect selection of the best technology. That selection has been made and formalized in the decision document, and hence, the primary focus of uncertainty management during design relates to those conditions/parameters that impact the design of the selected response. The ideal time to consider and account for uncertainty impacts on design is when the design basis is being set. A design uncertainty matrix can be utilized to assist in the process.

4.2.2 Design Uncertainty Matrix

The uncertainty matrix was first developed to evaluate the impact of deviations from assumed conditions on the performance of candidate responses. By carrying over the response selection uncertainty matrix and adding supplemental data columns, the matrix becomes a useful tool for organizing information on design uncertainty and developing the necessary contingencies to counteract potential adverse impacts. The format for a sample design uncertainty matrix is provided in Exhibit 14.

Exhibit 14: Example of an Uncertainty Matrix

Component	Design Basis	Range	Threshold	Impact	Probability	Monitoring	Contingency	Time to Implement

For each component of the response, the design engineer must identify all relevant conditions and parameters that will determine the design basis. (Example listings for common responses are provided in Appendix E.) For each condition/parameter the designer estimates a probable state/value. This will be the basis for the design. The opportunity for actual states/values to differ comprises the uncertainty that the engineer must manage. Therefore, once the design basis is set, it is necessary to identify the full range of states/values that could reasonably be observed during implementation. For instance, if the design is based on an anticipated 1,000 cubic yards of contaminated soil that will be excavated, the actual value may fall in the range of 750 to 5,000 cubic yards depending on how the contamination is distributed in the subsurface.

After determining the most probable estimate used for the design basis, it is important to estimate the complete range of likely values or conditions. Bounding the range of probable values/conditions will allow the design engineer to understand the effects of potential deviations from the estimate on the overall remedy design. Developing the range of probable estimates should be determined through an analysis of the site conditions that were identified during the site characterization. Consider the example of the volume of contaminated soil. If the planned response is vadose zone excavation, the depth to the water table multiplied by the lateral distance to the nearest non-detect sample points will result in the maximum volume likely to be encountered. The existence of additional site data or known site features may allow the analyst to further shrink the upper bound from the maximum calculated. Since the goal of the bounding estimate is to examine the impacts of the extreme values, it is more important to include all possible values/conditions than to develop a conservative range. The consequences of too narrowly defining the design estimate are greater than the consequences of over estimating since a narrow definition may result in encountering conditions for which there was no preparation during the design phase. Exhibit 15 presents several approaches to assist the designer and analysts in selecting a range of values that comprise the uncertainty parameters. This list can also be used by project managers and members of the core team to critically review the proposed design basis, and to evaluate uncertainties.

Exhibit 15: Alternate Approaches to Selecting Value Ranges for Uncertain Parameters

Bimodal Conditions (Condition is either present or not present)

- Presence of underground utilities
- Need for a permit
- Presence of co-contaminants or other forms of contaminant (e.g., hazardous chemicals, radionuclides, different valence states, interfering species)
- Presence of cultural resources/ artifacts
- Presence of openings in confining layers

Parameters With A Range Of possible Values

<u>Depth of Contaminated Soil</u>
- Range of values from field sampling and analysis
- Range defined by deepest and shallowest non detect samples
- Depth of water table
- Depth to impermeable layer

<u>Areal Extent of Contaminated Soil</u>
- Waste management unit boundaries or footprint of release
- Non detect isopleth
- Extrapolation of data using geostatistics
- Distance to physical barriers
- Estimate based on probable flow paths from stratigraphic logs

<u>Volume of Contaminated Soil</u>
- Calculated from combination of ranges for depth and areal extent

<u>Thickness of Ground Water Plume</u>
- Range of values from field data
- Range defined by shallowest and deepest non detect samples
- Depth to aquitard
- Thickness of aquifer
- Thickness of stratigraphic unit

<u>Areal Extent of Ground Water Plume</u>
- Range of field detection data
- Maximum and minimum dimensions from field data
- Geostatistical extrapolation

<u>Volume of Ground Water Plume</u>
- Calculated from combination of ranges for thickness and areal extent

<u>Waste type</u>
- Radioactive, Hazardous, Mixed

Exhibit 15 (continued): Alternate Approaches to Selecting Value Ranges for Uncertain Parameters

Soil Characteristics and Properties
- Range of values from boring logs and/or test pits
- SCS soil survey data
- Regional soil or geologic studies
- Range of values for soil class based on values from reference text (e.g. Freeze and Cherry)
- Infer from other properties or test results

Aquifer Hydraulic and Soil Vapor Properties
- Range of values from field data
- Range of values for media type from reference text e.g. (Freeze and Cherry)
- Order of magnitude ranges:
  1) Hydraulic conductivity, factor of 1,000
  2) Porosity, factor of 2
  3) Gradient, factor of 10

Site Access/Logistics
- Overlay site map with estimated range of areal extent

Chemical Concentrations
- Range of values from field data
- Statistical extrapolation of data
- Phenomenological limitations e.g. solubility, vapor pressure, partition coefficient

Treatment Efficiencies
- Range of values from treatability studies
- Range of literature values for the technology

By-Product Generation
- Calculate from range of chemical concentrations
- Value range from literature on the technology

Depth to Water Table
- Range from seasonal hydrographs
- Extrapolate from regional hydrographs
- Estimate based on water balance calculations

Weather/climate
- Range of values from local weather station historic data
- Range of values from SCS soil survey reports

Once the range of possible values or conditions has been estimated, the analyst must determine if there is a threshold value within the range which if exceeded, would have a significant impact on the implementability or effectiveness of the response. For instance, in the excavation example, if there is capacity to treat/dispose of up to 2,500 cubic yards of contaminated soil, any volume beyond that will require alternate means of management. Therefore, the threshold would be 2,500 cubic yards. If the range of possible values exceeds the threshold (e.g., in this example, anything between 2,500 cubic yards and the estimated upper bound of 5,000 cubic yards), then the designer must evaluate the impacts of exceeding a threshold and develop contingency plans.

It is important to note that in some cases (i.e., where it is difficult to calculate the upper bound for the range of possible values, but a threshold is obvious), the analysis can be conducted by using the threshold as a benchmark and asking whether the value for the parameter could exceed the threshold. If the response is negative (i.e., the parameter can not exceed the threshold), there is no need to provide a value for the upper bound and the design can proceed.

The significance of the impact depends on the nature of the response and the relation between the design basis and the maximum possible deviation. In an extreme case, a deviation may invalidate the entire technical approach and require selection of an alternate technology. Presumably, such extreme impacts have been ruled out much earlier in the process through sufficient investigations to reduce the uncertainty. It is far more likely that deviations will have a negative impact on cost or performance. Whenever the impact of deviations is judged by the core team to be significant, a contingency is needed to counteract the impact.

Contingency plans may vary from simple design modifications to complete changes in technology depending on the significance of impacts. Selection of contingency plans in this phase is analogous to a feasibility study in the pre-ROD phase in that the analyst is looking for the best alternative under a given set of circumstances. However, in this case, there is a response selected and in progress, and a specific deviation from expected conditions has occurred that requires implementation of the contingency. Selection of the contingency is based on the same factors relative to protection of human health and the environment, implementability, and cost. Additional considerations include compatibility with the ongoing activities and time to implement. Obviously, once response is under way, there is a desire to conclude it without major delays. Delays will drive up cost and could drive up risks related to the incomplete nature of the response. Consequently, there may be a premium on contingencies which can be implemented in a seamless fashion.

For those conditions or parameters which have a range of possible values that exceed the threshold, the analyst needs to determine if the probability of exceeding the threshold is high, medium, or low. This qualitative categorization of probability will help determine the efficacy of having contingencies pre-mobilized as opposed to a plan to halt work for mobilization only after the deviation is encountered. Any finer cut on probability than the three general categories is likely to be beyond the analysts ability to differentiate and will serve no real purpose. In many cases, a binary categorization of likely and not likely will suffice.

For potentially significant deviations, it is important to monitor conditions to provide a warning as early as possible. Clearly, in some cases, the first indication of a deviation does not occur until the deviation is observed. Examples include the presence of hazardous chemicals in what was thought to be only radioactive contamination, or a change in media characteristics such that a stabilized product will no longer meet waste acceptance criteria. However, for other deviations, there may be means of predicting their likelihood in advance. For example, by extrapolating dig face concentration data, it may be possible to improve the precision of contaminated soil volume estimates. Chemical trends may also be helpful in presaging a change in status such as a shift from trivalent to hexavalent chromium. Regardless of how much advance notice can be obtained, some form of monitoring is required for contingency plans to be of value.

Examples of completed design uncertainty matrices are provided in Exhibits 16a and b.

Exhibit 16a: Example Completed Uncertainty Matrix (Soils)

The uncertainty matrix below was completed based on the following text:

The client had soil contaminated from discharge of chrome plating materials. Company records indicated that the effluent had been treated to reduce all hexavalent Chromium, Cr(VI), to trivalent chromium, Cr (III), then discharged it to a drying pond. Field sampling had been conducted and provided a three-dimensional array of data indicating a large, irregular shaped volume of soil containing Cr(III) only. Geophysical surveys and a cursory look at plant layouts indicated no underground utilities in the area. Armed with that "knowledge", a procurement was prepared in which the bidder would offer a fixed unit price bid for excavation, stabilization of the chromium in cement, and subsequent reburial. A minimum volume of soil was guaranteed. The contractor was required to use x-ray fluorescence to monitor total chromium levels during excavation. A cut off value for total chromium was used to segregate clean soils from those requiring stabilization.

Component	Design Basis	Range	Threshold	Impact	Probability	Monitoring	Contingency	Time to Implement
Excavation	No utilities	Water Storm sewer Electrical	Any one utility	Halt excavation Damage or disrupt service	Low	Visual	Cocoon Hand dig	1-2 day 1-2 day
	Only Cr (III) present	Cr (VI) present	> RCRA limits	Remedy illegal w/o treatment Delay while new plan approved Revised H&S plan Additional staging areas Delays in analytical services	Moderate	Field wet chemistry Visual	Contract to ship/treat off-site TSD Reduce to Cr (III)	30-60 days if contingency not developed, including all permits and contracts, prior to implementing response

Exhibit 16b: Example Completed Uncertainty Matrix (Ground Water)

The uncertainty matrix below was completed based on the following text:

Treatment was selected as aqueous phase activated carbon. Monitoring data indicated that the plume was dissolved and carbon adsorption would readily remove contaminants of interest. When the system was installed, it was estimated (expected) that there was no associated free product.

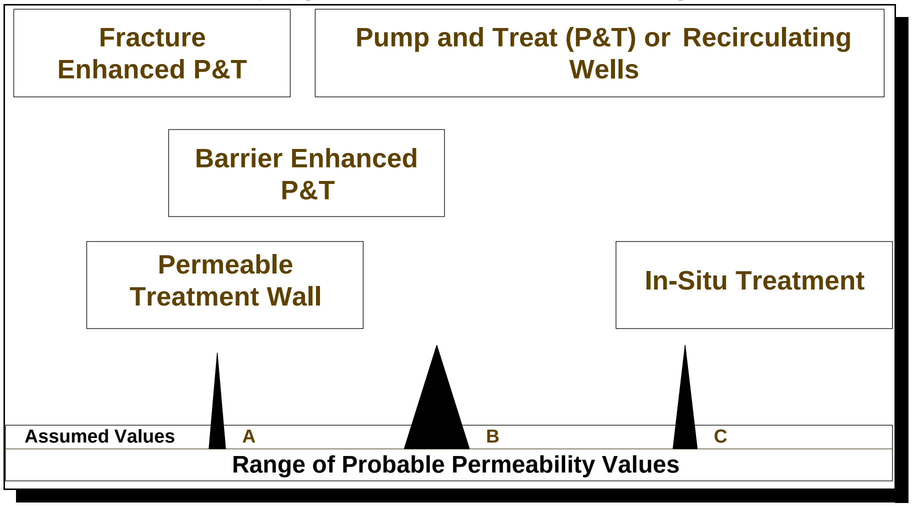
Component	Design Basis	Range	Threshold	Impact	Probability	Monitoring	Contingency	Time to Implement
Pump and treat with aqueous GAC	No NAPL present	Free floating product in zone of capture	>sheen	• Fouls GAC • Stops work • Drives up costs by reducing efficiency	Moderate	On-line collection cell or grab samples	Separation module or pre-filter	3 months to install after response initiated

4.2.3 Systems Analysis

When the uncertainty matrix has been completed for all conditions/parameters related to all components of the response, the analyst should review the more significant uncertainties and associated impacts to see if a different design basis is warranted. This is the first of the iterations used to continuously re-evaluate design decisions in a systems context. The intent is to see if an alternate design basis would reduce contingency requirements sufficiently to constitute a lower overall expected life-cycle cost or a higher probable level of performance. Because some of the design parameters are uncertain, the engineer is assessing likely costs by looking at the product of the probability of a deviation and the cost of the contingency needed to counteract its effects. Therefore, in the end, the engineer must strike a balance between the cost of the response for a given design basis and the cost of the associated contingencies that may be required to accompany it.

For sites with greater degrees of uncertainty, there will be greater value in robust designs that can accommodate wider ranges of conditions and parameter values i.e., designs that have higher associated thresholds for key design parameters. Robust (or tolerant) designs are defined as those that can accommodate the broadest range of conditions. Ideally, a design is available that addresses the full range of probable values for the uncertain parameter. As shown in Exhibit 17, the location of the assumed value (A, B, or C) would alter the selection of the response. If, for example, the assumed value is A, pump and treat cannot be applied without enhancements. If B or C are the assumed value for permeability, pump and treat/ recirculating wells are the most robust design.

Exhibit 17: Identifying Tolerant, or Robust, Designs



Completing the uncertainty matrix is an instructive way to characterize a given designs robustness and explore the advantages of alternatives. The matrix enables the designer to look at individual components and then explore the impact of decisions on the larger system. While it is unlikely that the designer can select a single best value for every component in the design basis, it is highly likely that through this iterative examination, the impacts of unexpected conditions can be minimized.

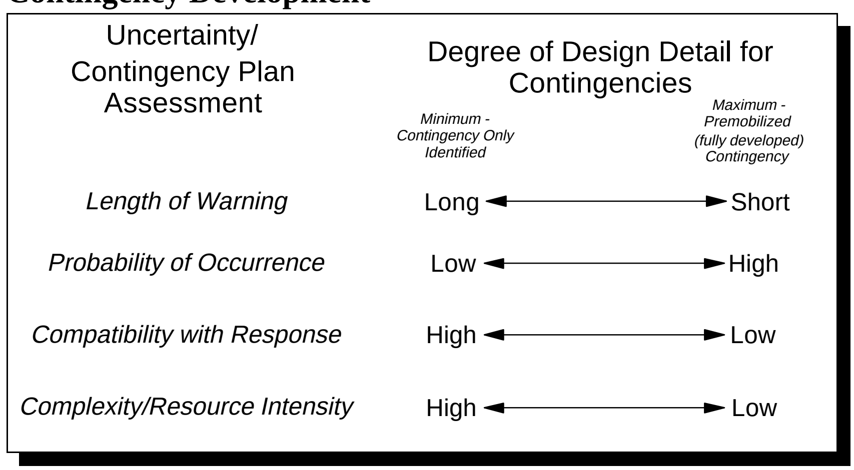
Once the optimal design has been selected, the uncertainty matrix will include the identity of those contingencies which may be required to complete the response should deviations from the design basis be encountered. Ideally, specifications and details would be developed for the response and the contingencies at this point. However, some degree of judgment is required before launching into full-scale design of all contingencies (as discussed below).

4.2.4 Contingency Design

Clearly, if the impacts will cause performance or safety concerns or if the timing involves unacceptable work stoppages, there are incentives to have contingencies pre-mobilized and ready to implement as soon as monitoring indicates a change from the design basis. At the same time, the design and mobilization of contingencies can add substantially to the cost of response. If the likelihood of encountering a deviation that would necessitate a contingency is of low probability, it may be prudent to forego mobilization until the need for it is more certain.

In general, the designer has a full range of options for how far to develop contingencies. As shown in Exhibit 18, the appropriate level of development will depend both on the nature of the contingency and the likelihood of the need for it. Examples of differing levels of design and pre-mobilization for different sets of conditions are provided in Appendix F. In this context, a robust design can be viewed as a contingency completely executed in advance.

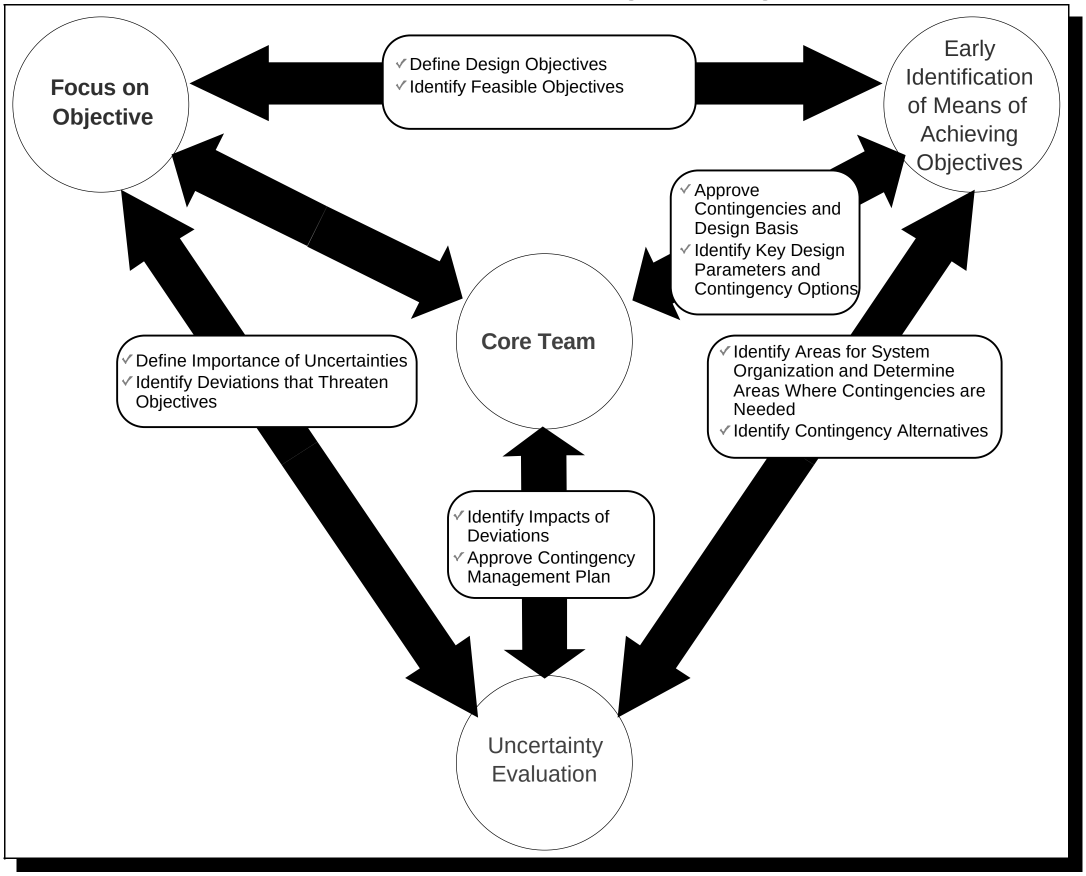
Exhibit 18: Several Factors Influence the Degree of Contingency Development



The decisions regarding how much of the contingency is pre-mobilized as well as the extent to which the contingency is incorporated in the design should be included as an integral part of the uncertainty management plan. This plan requires core team approval along with guidelines as to the level at which decisions are authorized for implementing each contingency when monitoring results so indicate. In general, the level of delegation is coincident with the degree of pre-mobilization. Authorization to implement fully pre-mobilized contingencies may be delegated to the implementation contractor with the need only to notify the core team. Implementation decisions for contingencies that are identified in concept only will likely be retained by the core team.

Exhibit 19 illustrates the interrelationship of the principles while selecting the design basis.

Exhibit 19: The Principles When Establishing the Design Basis



4.3 Design

At this stage, the design engineer proceeds with development of detailed designs and specifications to complete the design package. Each new design calculation or consideration may trigger the need to feed information back through the uncertainty matrix to determine potential impacts and see if a new optimal design emerges when all factors are considered. Iterations are especially warranted when new assumptions are required during the development of the design. With each iteration, the designer has another opportunity to optimize the overall response and to identify innovative ways to reduce cost and time requirements.

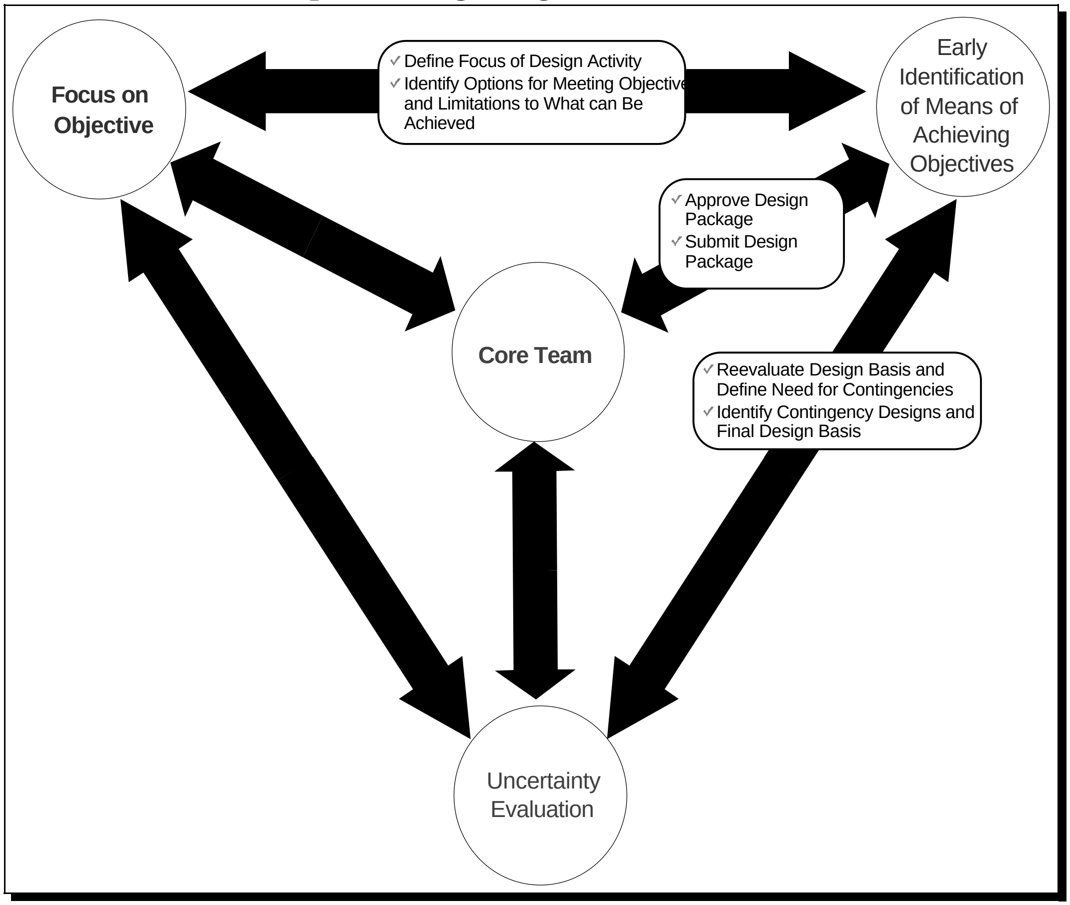
In addition to developing detailed specifications and plans for the response, design activities include development of particulars for the monitoring by which the core team will determine when contingencies should be implemented. The approach to monitoring should have been identified during construction of the uncertainty matrix. During design activities, the details of how the monitoring will be conducted must be developed if they have not been done previously. Key considerations include:

- What to monitor
- Where to monitor
- How to monitor
- How often to monitor
- How to process the results of monitoring e.g., statistical tests or translation of secondary parameters to the target parameter, etc.

All of these details become a part of the design package and must be specified in any implementation contractor procurement unless third party monitoring is specified in the project delivery strategy.

Depending on the approach selected by the core team, performance measurements procedures also may need to be developed in the design package. Third party performance monitoring is desirable, but not essential. Whether data are generated by the implementation contractor or a third party, some means of verification should be considered. The regulatory members of the core team may be best suited for that function. The completed design package is presented to the core team for approval prior to implementation. Exhibit 20 illustrates the interrelationship of principles during the design phase.

Exhibit 20: The Principles During Design



5. Implementing The Remedy

5.1 Introduction

For most sites, a significant amount of time, effort, and money has been spent to arrive at this point. And yet, in a very real sense, all of that effort has not provided a single material benefit by way of improved environmental quality or reduced risks. At best, some of the investigative efforts may have helped reduce perceived risk. However, it is the activity that is about to begin that will mark real progress and put value to all of the previous effort.

If the design activity has been performed properly, implementation should proceed smoothly. While deviations from design assumptions can be expected, the contingencies developed in the uncertainty management plan should allow for appropriate transition when they are encountered. Barring major disruptions from unanticipated events, implementation proceeds in two steps:

1) Simultaneous conduct of implementation, performance measurement, and deviation monitoring; and
2) Documentation of construction completion.

To the extent that contingency implementation is required, there may be a hiatus in activities depending on the level of pre-mobilization selected for those contingencies. Otherwise, the first step is a continuous process. While the second step can not be completed until the first is concluded, a significant portion of the work effort has already been performed in earlier activities as will be discussed in the text.

Role of the Project Manager During Implementation

- Continually assess the adequacy of contingency and monitoring plans
- Monitor conditions specified in the implementation contract;
- Determine when change orders are required;
- If deemed necessary, convene the core team to evaluate possibility of revising procurement strategy, implementing contingencies, etc.
- Continually seek opportunities to improve technical design and/or implementation;
- Continually evaluate field observations against the design basis to identify unexpected conditions early, and to evaluate against triggers for contingencies.

5.2 Implementation

In its simplest form, implementation consists of merely following the instructions provided in the design package. The exact nature of implementation activities is dictated by the response selected, the design employed, and residual uncertainty left for management by contingency. As such, no further discussion is provided herein.

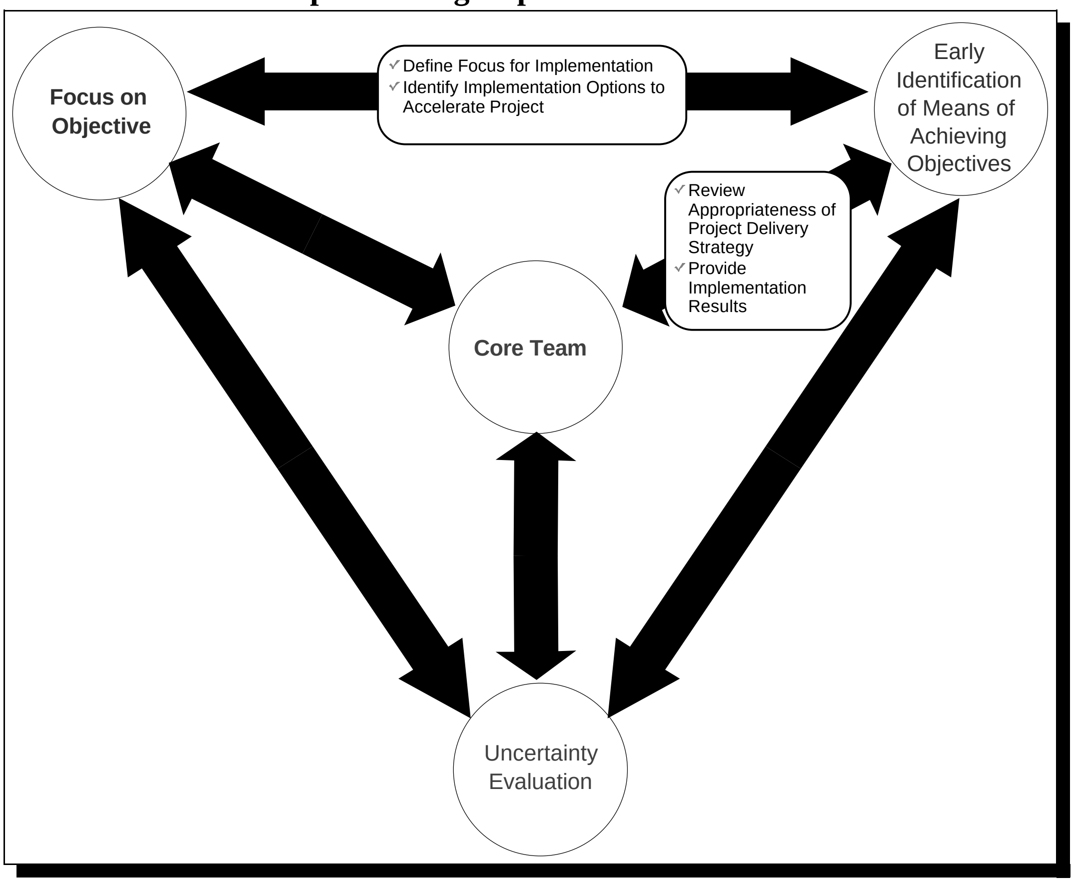
To the extent that a decision has been made to manage any residual uncertainties by contingency, the success of the implementation effort may hinge on the quality of deviation monitoring and pre-mobilization efforts, as well as the response itself. No contingency plan can counteract negative impacts from deviations if the deviations are not recognized when encountered or if the contingency is not implementable. Therefore, the project manager must assess the adequacy of implementation of monitoring and contingency plans in addition to the response itself.

Depending on the contract vehicle selected, the project manager may also need to monitor conditions specified in the implementation contract. To the extent that fixed price contracts are utilized, the project manager needs to determine when change orders are justified and the true nature of the additional effort. If conditions are such that too many change orders arise or the original contract is found to be inappropriate, contract administration and procurement officials should be brought in to discuss possible changes in the project delivery strategy; again, emphasis is placed on the opportunity of discreet points being incorporated into the contract itself.

As the work progresses, the project manager may also observe opportunities to use knowledge gained and experience to improve on the technical design and/or implementation. Whether done within the context of continuous quality improvement, other related programs, or simply as a part of prudent oversight, the project manager should continually evaluate field observations against the design basis and specifications to see if actual conditions would be better served by modifications. In general, such considerations are most likely to arise from uncertainties related to deviations from the design basis that fall short of a threshold for which contingencies have been designated.

Exhibit 21 illustrates the interrelationship of principles during the implementation phase.

Exhibit 21: The Principles During Implementation



5.3 Monitoring For Deviations

During the development of the design uncertainty matrix, an effort was made to identify an appropriate monitoring technique for any potential deviation from the design basis which would require subsequent implementation of a contingency. Details on how those techniques should be deployed, how often to monitor, and where to monitor should all be specified in the design package. During implementation, the project manager must see that the monitoring is conducted in accordance with those specifications.

Results of deviation monitoring should be supplied to the core team for evaluation. Presumably, the core team will ask for periodic summaries highlighting any findings or trends that may foretell impending deviations of significance. The frequency of reporting will depend on a number of factors, including:

1) Specific requests from the core team;

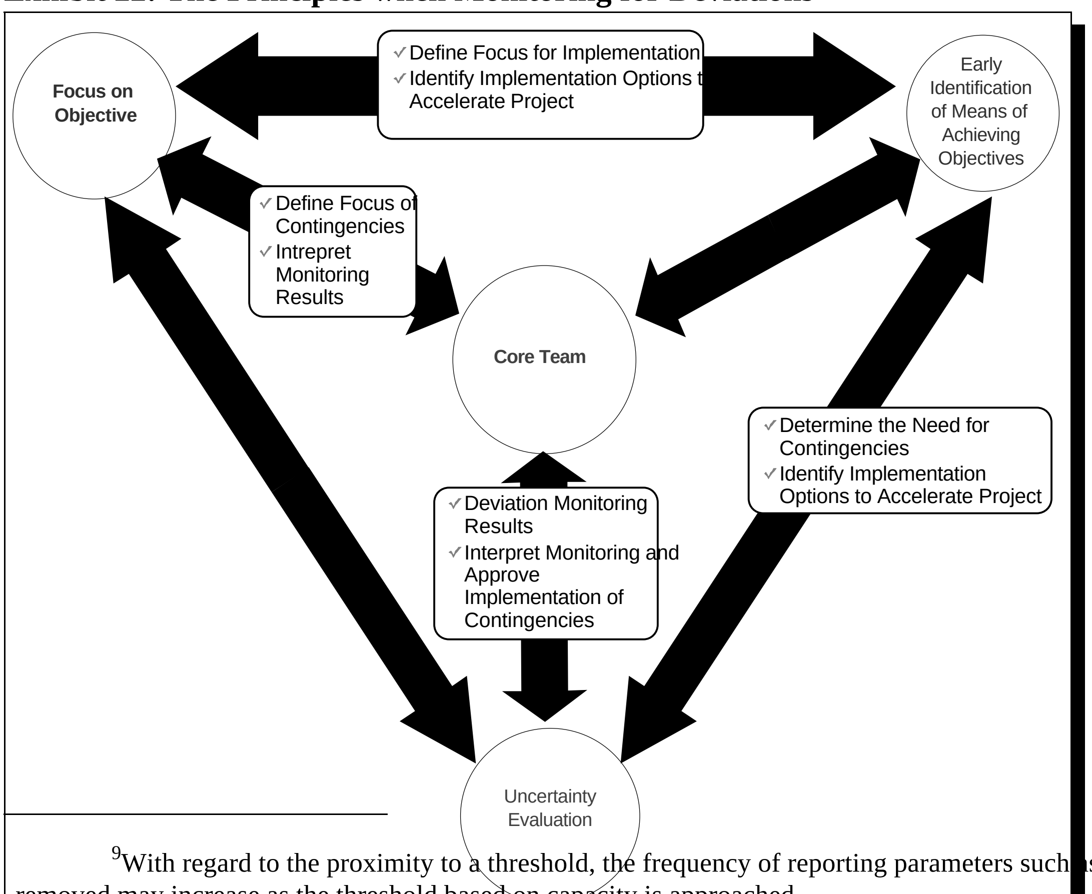
2) Nature of the deviation on which the monitoring is focused;

3) Level to which authority to implement a remedy has been delegated; and

4) Proximity of trended data to a threshold of concern.[9]

Exhibit 22 illustrates the interrelationship of principles when monitoring for deviations.

Exhibit 22: The Principles when Monitoring for Deviations



[9]With regard to the proximity to a threshold, the frequency of reporting parameters such as volume of soil removed may increase as the threshold based on capacity is approached.

5.4 Measuring Performance

Throughout implementation, there is a need to measure progress towards the ultimate objective of the response. An approach to performance measurement should have been selected by the core team during planning/scoping activities. To the extent that the selected approach requires equipment and special practices on the part of the implementation contractor or a third party observer, detailed specifications should have been developed during design.

Performance measurement is often utilized to fulfill several needs, including:

- Monitoring implementation contractor performance for project management considerations
- Monitoring residual uncertainties related to the effectiveness of a response action to determine if any of the uncertainties are realized or occur
- Measuring progress for communication to stakeholders

With respect to measuring contractor performance, results can be used to estimate the likelihood of meeting schedules, as well as to calibrate earned value and progress payments that may be specified in the contract.

Performance measures that verify material progress are a key element of continuing communication with stakeholders. Both the public and the regulatory community will want to be updated with accurate information on how objectives are being met. For this purpose, the more direct the metric applied, the greater its value. The core team will need to decide on the frequency and venue for reporting to the public. Early in the process, a higher frequency may be warranted, followed by less frequent communications as risks are reduced and the community gains confidence that implementation is going according to plan. Conversely, the frequency may need to be increased if difficulties are encountered or contingencies need to be implemented.

The nature of communications also will be affected by the degree to which restoration results from construction/implementation activities as opposed to long term post-construction operation and maintenance. When the response involves physical removal such as soil excavation, the objective is to remove contaminant mass which can be measured directly. Moreover, closure is commensurate with completion of construction. For a response such as pump and treat, construction merely puts the tools in place to start making progress during the post-construction operation. While it is easy to think of the objective as completion of construction, the truth is, when construction is complete, there still has been no material improvement in aquifer quality. Should the design be insufficient, progress towards the real objective may be long in coming. Hence, the core team needs to be sensitive to how progress is defined and portrayed in these situations.

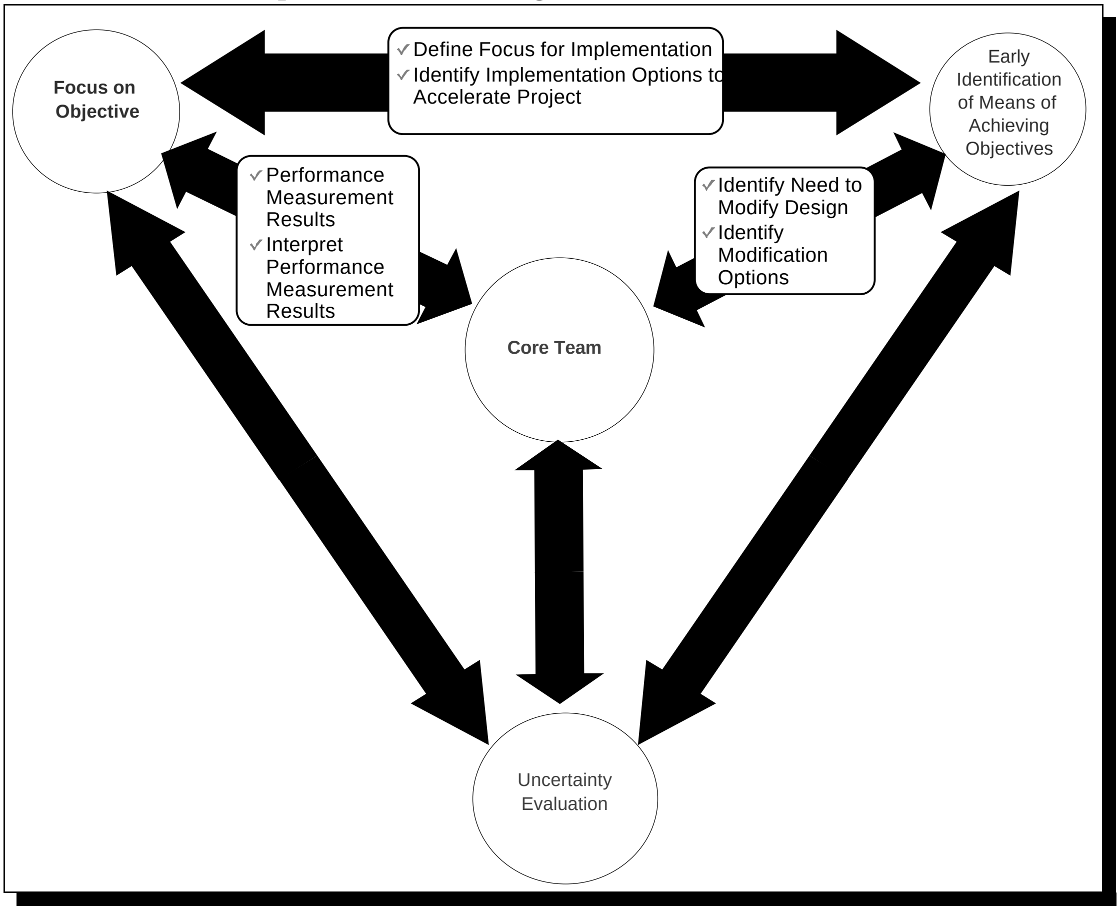
For technologies that rely on long term operation or other post-construction stewardship activities (e.g., capping, pump and treat, or barrier walls), performance measurement has a large after-implementation component which can not be distinguished from deviation monitoring associated with the uncertainty that the design will perform as intended. Were we completely confident of a technology and our design, no long-term monitoring would be required. We would implement a response, verify that we satisfied the design specifications, and walk away secure in the knowledge that the technology will perform its task.

An attempt has been made to segregate performance measurement and deviation monitoring to highlight two very different objectives for overall monitoring activities. That should not be taken as a sign that two separate monitoring systems are needed. Indeed, if the two can be integrated in a single system, so much the better. The concern is that all measurements be considered, not that each have its own unique monitoring system.

In reality, uncertain site conditions and uncertainties associated with the applicability of a given design to a specific site, leave open the question as to whether a response will perform as intended. As with all other significant uncertainties, a monitoring plan is employed to alert us to the possibility that the design will not meet our objectives. In this context, any response that requires long-term monitoring should also be accompanied with a contingency plan for the potential determination that the response is not meeting its objective. If at least a notion of how to respond to an indication of failure is not developed, then the monitoring program violates a basic tenant of streamlined environmental response, namely that no data are collected for which there is not a need and a plan for responding to the data.

Exhibit 23 illustrates the interrelationship of principles while measuring performance.

Exhibit 23: The Principles When Measuring Performance



5.5 Construction Complete

5.5.1 The Completion Report

For most response actions, there will be a need to document the fact that construction has been completed. Issuance of a related report may even be a milestone in a Federal Facility Agreement or a related target against which progress is to be marked. While these may be important procedurally, the real value in preparation of the completion report is to document what was done and what was observed during construction, as well as to support future stewardship activities.

The nature and finality of a completion report will depend on the type of action taken. For definitive responses such as excavation and removal of contaminated soils, completion of construction will likely coincide with site closure. Hence, the completion report could conceivably constitute the final activity in the environmental response program at that site.

For containment designs or other approaches requiring long-term stewardship, completion of construction merely signals the transition to a new phase of the program. For sites selecting these responses, the completion report may be followed by a closure report many years later. In some instances, there may be no single closure report but a series of periodic-update reports, in that residues are to be managed in perpetuity.

Regardless of whether the completion report is coincident with the closure report or not, it serves a primary function in becoming the authoritative source on the response action. The completion report is analogous to as-builts in the construction industry. As such, it should focus on clearly recording what was done and how, rather than what was planned. Moreover, there is little merit in providing a lengthy history of site operations and the investigation phase. The investigation reports provide that information and the decision document provides a summary of the more important highlights up to the point when a response was selected.

5.5.2 Report Contents

A brief description of the main sections of a completion report and the source of the materials for those sections is provided in Appendix G. It should be readily apparent from the review of Appendix G that <u>most of the content of the completion report has been developed during the course of the restoration project. Therefore, there is not a need to generate a large volume of new material</u>. This document should be concise and to the point.

- The <u>problem statement</u> should briefly summarize the site conditions for which a response was required. The problem statement should have been developed in early scoping materials and is likely to be restated in the decision document. There is no need to elaborate on how the condition came about or its discovery. That type of historical information is provided in earlier documents and is of no real significance once the response has been implemented.

- The description of the <u>selected response</u> should come from the decision document with any additional information generated by the core team when interpreting that document. There is no need to describe alternatives that were considered, but not selected. Contingencies that were ultimately applied should be addressed, but not those for which no use arose.

- The <u>details of implementation</u> does require new information generated during design and implementation activities. This section should contain both text and drawings to provide a complete and accurate set of as-builts which will guide future parties that may need to add to, modify, remove or otherwise interact with any remaining structures or residues. Input for this section should be developed on an on-going basis during implementation and includes logs, sketches, memoranda, briefings, field notes, and other materials generated by the implementation contractor, monitoring contractor, regulators and project manager during the normal course of their activities. An as-built verification task may be helpful to assure that all deviations from the design package are captured and preserved for inclusion in the completion report.

- A separate section should be provided to describe any contingencies that were implemented during the construction phase. While the use of some contingencies will be obvious from the as-builts in the previous section, it is important to address all contingencies in a clearly marked segment to alert the reader to areas which differ from the original plan, as a means of documenting activities that may not be evident from drawings (i.e., use of alternate means of transport or excavation to remove waste materials from the site), and to create a resource for use in future restoration efforts facing similar challenges. Much of the input for this section should exist in memoranda and briefings developed when contingencies were authorized for implementation.

- The report should contain a brief summary of the results of all performance measurement and deviation monitoring activity conducted during implementation. Significant or unexpected observations should be highlighted and a copy of all data should be appended. Recognizing that results will be a part of the completion report, a format should be specified in advance so that materials can be used directly as received from suppliers/contractors to the extent possible.

- The report should contain a section with the interpretation of the monitoring data as a means of verifying that construction is complete and the objectives set for construction completion were met. **This is a section that must be written specifically for the completion report and, while drawing upon existing data, comprises one of the few original pieces that must be prepared upon conclusion of the construction itself.**

- For sites where there will be post-construction activities, the completion report should have a section that describes the nature of those activities. Candidate materials would include a description of operation and maintenance requirements, a discussion of deed and use restrictions, and a plan for all monitoring activities. Pieces of this section will come from the decision document, the design package, as-builts, and operations manuals.

To the extent that closure follows some time after completion and that there are post-construction activities occurring in the interim, there may be need for a subsequent closure report. The second report should be based on the completion report with new materials added that reflect performance measurement and monitoring results over that period.

6. Post-Construction Activities

As noted in the preceding sections, for many activities, objectives are not fulfilled at the time that construction is completed. For example:

- Pump and treat response will require varying periods of operation to capture and remove contaminants from the saturated zone. For slower migrating chemicals (more highly retarded) with large residual masses in the saturated zone (e.g., dense non aqueous phase liquids) and low permeability aquifers, the time frames could be tens to hundreds of years or more.

- In-situ responses such as permeable barriers are based on natural transport of contaminants to the barrier which, depending on chemical and hydrogeologic properties can take many years.

- Containment through use of caps or barriers may require maintenance in perpetuity, as well as use covenants such as deed restrictions.

- Monitored natural attenuation will likely require some level of continued monitoring as long as residues above threshold concentrations remain in the environment.

In order to ensure that objectives are met, the core team must ensure that provisions are in place for associated long-term care requirements. The nature of long-term care requirements should be identified for a site in the decision document. Details for structures, facilities, monitoring points, and supporting materials should be provided in the design package. Operating procedures should be developed in manuals produced as a part of the implementation activities to accompany transition to the operations contractor. The means by which long-term care services will be provided should be defined in the project delivery strategy. To the extent that all these conditions prevail, passage into post-construction activities will be relatively smooth. Indeed, for many responses with operational requirements, the construction phase will include a shakedown and start-up task so that an operating facility is handed over to the long-term care contractor at the time of transition.

To the extent that a site is not closed and certified as having no contamination, the principles of environmental restoration remain pertinent in the post-construction phase. The activity of the core team on a given site will decrease sharply after completion of construction, but there are still decisions to be made with respect to ongoing activities. At a minimum, the core team must be involved in the CERCLA mandatory five-year review process, where applicable. There will also be monitoring data to review and stakeholder communications concerning the results of the monitoring.

All post-construction activities should be focused on the objectives. Therefore, the five-year reviews (or other post-closure care requirements) and any consideration of change at a site should be made in the context of that objective. The addition of new features and continuation of activities alike should be scrutinized to determine if they add value to the remaining milestone, i.e., a decision that closure is at hand. As long as uncertainties remain with respect to protection of human health and the environment, monitoring must continue along with a plan for what to do should the monitoring reveal that the response is not meeting the objective. When protection is proven with certainty and no future risks can be envisioned, all activity should be terminated.

Appendix A: Example Interpretation Of A Decision Document

This Appendix is provided to illustrate how a decision document may be interpreted. The decision document selected for interpretation is a relatively simple one. And yet, it includes apparent ambiguities as well as areas clearly providing a great deal of flexibility. There is no correct interpretation of these areas. The correct answer is that which the core team can reach consensus on. Therefore, this exhibit should be viewed only as an example of how an interpretation may be developed.

The following is a modified excerpt from the Selected Remedies portion of a record of decision at a CERCLA site. The identified problem at the site is the presence of VOCs, metals, and radionuclides in soil and ground water at levels that threaten off-site ground water quality should they migrate across site boundaries. To illustrate how a core team might interpret such a decision document, the modified text is offered in its entirety followed by highlighted excerpts that indicate the specific requirement or allowance of interest. The objective of this example is to indicate where in the document one can find specific elements and how those elements might be interpreted. The intent is not to suggest that the interpretation offered herein is the only interpretation or even the best interpretation. Ultimately, the right interpretation is the one on which the core team can reach consensus.

1.0 The Selected Responses

a) *Based on the requirements of CERCLA, the detailed analysis of the alternatives, and public comments, [the owner/operator and regulatory entities] have determined that Alternative No. 1 for ground water (pumping and surface treatment by UV/oxidation and air stripping), and Alternative No. 5 for the unsaturated zone (soil vapor extraction with catalytic oxidation of the extracted vapors) are the most appropriate responses for the site.*

b) *The selected responses for this site protect human health and the environment, comply with Federal, State, and local requirements (ARARs), are implementable, and permanently and significantly reduce the toxicity, mobility, and volume of the contaminants.*

c) *The goal of this response is to remediate ground water to the ARARs specified in the PRAP and the decision document. Based on information obtained during the site investigation and on careful analysis of all alternatives, [the decision making authorities] believe that the selected response will achieve this goal. The approach to be taken will involve close monitoring of ground water quality in monitoring wells, extracted water quality in extraction wells, and water level elevations near extraction centers. The extraction well field will be operated dynamically to optimize the cleanup. That is, based on the results from the monitoring plan, individual wells may operate continuously, may be turned off, or may be pumped intermittently. During the course of the response, new wells will be installed at appropriate locations and will be operated in the same manner.*

d) *To ensure that cleanup levels continue to be maintained, the ground water will be monitored until the regulatory authorities agree that cleanup is complete.*

1.1 Ground Water

a) *The primary purpose of the selected ground water remedy is to contain VOCs and prevent further downgradient and offsite migration in ground water, and to reduce the concentration of contaminants in ground water after cleanup to levels below MCLs, the designated cleanup levels. Existing conditions at the site may pose an excess lifetime cancer risk of 2 x 10-3 from ingestion* *of ground water contaminated with VOCs (primarily TCE) under health-conservative no response assumptions. The selected alternative will address all ground water contaminated with VOCs in excess of 5 ppb and will assure that ARARs for individual VOCs, FHCs, lead, chromium, and tritium will be achieved.*

***b)** The selected ground water response involves immediately pumping water at approximately 18 initial locations within the ground water plume (Figure 12). The total rate of ground water removal for this extraction plan is estimated to be about 350 gpm. Water will be pumped from one or more wells at each of these locations using existing monitor and extraction wells, along with new extraction wells. The well locations will be chosen to prevent any VOCs from escaping from the area in concentrations above their MCLs. To enable more rapid restoration, wells will also be placed in all areas where VOC or FHC concentrations in ground water exceed 100 ppb. Additional extraction locations may be added to ensure complete hydraulic capture of the plume, and/or to expedite cleanup if field data indicate additional wells are necessary.*

***c)** Seven onsite facilities (A to G) will be constructed initially to treat the extracted ground water (Figure 12). Each treatment facility will be designed to treat a somewhat different combination of compounds. Treatment facilities A, B, E, and F will use UV/oxidation as the primary treatment technology. Treatment Facilities C, D, and G will use air stripping as the primary treatment technology. All facilities will use GAC to remove VOCs and FHCs from air streams, and Treatment Facility F will use GAC to remove lead from ground water. Treatment Facility D will use ion exchange to remove chromium from ground water.*

***d)** The maximum additional cancer risk after remediation is complete is calculated at 7 x 10-8 using the best estimate assumptions. This is over 100 times lower than the 1 x 10-4 to 1 x 10-7 acceptable level of risk specified in the NCP (U.S. EPA, 1990). The HI for this scenario is far less than 1.0, indicating that no adverse health effects from noncarcinogens would occur following the planned response. Using health-conservative assumptions that EPA prescribes for assessing site risks, the risk of cancer after remediation, based on a potential monitor well drilled 250 feet west of the site is 4 x 10-5 and 3 x 10-5 for potential receptor wells in the nearest city. Both of these values are within the EPA acceptable risk range. The hazard indices for both health-conservative scenarios are far less than 1 (2 x 10-2 and 3.1 x 10-2, respectively), indicating no adverse health affects from noncarcinogens after the planned response.*

1.2 Unsaturated Zone

***a)** The selected remedy for the unsaturated zone involves using soil vapor extraction to extract contaminant vapors under pressure from the unsaturated sediments and treating the vapors by catalytic oxidation. Use of a catalytic oxidizer provides the flexibility to treat both FHCs and VOCs together and substantially reduces the potential for producing dioxin. The purpose of this response action is to prevent migration of VOCs and FHCs to ground water in concentrations that would impact the ground water in concentrations above MCLs.*

b) *Current data indicate that only FHCs in the Gasoline Spill Area, VOCs in the Building A Area in the southeastern part of the site, and possibly VOCs in the vicinity of the laydown yard will need unsaturated zone response. FHCs and/or VOCs will be removed from the subsurface by soil vapor extraction using extraction wells.*

c) *The selected treatment option for the extracted vapors is catalytic oxidation. In the process, vapors from extraction wells will be heated and passed through a catalyst, where organic compounds are converted to harmless oxidation products, including carbon dioxide and water. If use of catalytic oxidation should result in emission of vapors with compounds above regulatory standards, secondary treatment or alternative technologies, such as GAC, will be evaluated and implemented to comply with regulatory standards.*

d) *The decision regarding whether an area requires vadose cleanup will be based on unsaturated zone modeling and ground water monitoring. If modeling indicates that hazardous materials will impact ground water in concentrations above MCL, response will be implemented. Response will continue until in situ concentrations, as verified by soil sampling, are below those predicted to impact ground water above MCLs. In addition, the ground water near the potential source will be monitored for impacts on ground water quality. Details of the modeling and monitoring will be presented in the design package.*

2.0 Interpreting the Decision Document

2.1 The Problem Statement

Presumably, the problem statement would have been clearly articulated in preliminary sections of the decision document that have not been reproduced here. For the purposes of this example, the problem statement was indicated in the introductory materials. However, it can also be deduced from the stated goals for the response. Based on the objective of restoring ground water to quality levels below the MCLs and treating all soil areas capable of impacting ground water to levels above MCLs, the problem statement can be formulated as the presence of VOCs, FHCs, lead, chromium and tritium above MCLs in groundwater and at levels in the unsaturated sediments capable of producing concentrations in excess of MCLs in the future.

2.2 The Response Objective

The objective for the overall response is provided in Paragraph 1.0(c) as restoring the ground water to quality levels meeting ARARs:

1.0(c) *The goal of this response is to remediate ground water to the ARARs specified in the PRAP and the decision document. Based on information obtained during the site investigation and on careful analysis of all alternatives, [the decision making authorities] believe that the selected response will achieve this goal. The approach to be taken will involve close monitoring of ground water quality in monitoring wells, extracted water quality in extraction wells, and* *water level elevations near extraction centers. The extraction well field will be operated dynamically to optimize the cleanup. That is, based on the results from the monitoring plan, individual wells may operate continuously, may be turned off, or may be pumped intermittently. During the course of the response, new wells will be installed at appropriate locations and will be operated in the same manner.*

Subsequently, in Paragraph 1.1(a) the goal for the ground water portion of the response is further defined by identifying MCLs as the ARARs and by placing primary concern on stopping further downgradient and offsite migration of VOCs in addition to restoring all ground water to VOC concentrations below MCLs.

1.1(a) *The primary purpose of the selected ground water remedy is to contain VOCs and prevent further downgradient and offsite migration in ground water, and to reduce the concentration of contaminants in ground water after cleanup to levels below MCLs, the designated cleanup levels. Existing conditions at the site may pose an excess lifetime cancer risk of 2 x 10-3 from ingestion of ground water contaminated with VOCs (primarily TCE) under health-conservative no response assumptions. The selected alternative will address all ground water contaminated with VOCs in excess of 5 ppb and will assure that ARARs for individual VOCs, FHCs, lead, chromium, and tritium will be achieved.*

The text leaves room for confusion with respect to the ground water objective since it clearly identifies primary concern for VOCs and TCE in particular, yet requires meeting MCLs for FHCs, lead, chromium, and tritium as well. The core team will need to provide guidance for the design team with respect to which VOCs and FHCs are of concern. Furthermore, the text implies that the response must address water with total VOCs in excess of 5 ppb irrespective of the identity of the VOCs. This raises the potential for treating water that meets individual contaminant MCLs because their aggregate concentration exceeds 5 ppb. The core team will need to provide a clear interpretation of what concentrations apply: individual MCLs or the VOC aggregate of 5 ppb.

The decision document places equal importance in stopping further offsite migration and restoring onsite water to MCLs. However, since there is no time frame placed on the restoration objective for onsite waters, there is room to consider phasing such that a perimeter containment system could be installed in advance of the general plume restoration system.

With respect to the unsaturated zone, the overall goal is further elaborated in Paragraph 1.2(a).

1.2(a) *The selected remedy for the unsaturated zone involves using soil vapor extraction to extract contaminant vapors under pressure from the unsaturated sediments and treating the vapors by catalytic oxidation. Use of a catalytic oxidizer provides the flexibility to treat both FHCs and VOCs together and substantially reduces the potential for producing dioxin. The purpose of this response action is to prevent migration of VOCs and FHCs to ground water in concentrations that would impact the ground water in concentrations above MCLs.*

In particular, the soil response is designed to reduce VOC residues in soil to concentrations that will not sustain fluxes resulting in elevation of ground water concentrations above MCLs. No mention is made of FHCs, lead, chromium or tritium. Presumably, these contaminants did not originate in site soils or the sources have been depleted already. However, the core team must be in agreement with that assumption or must supplement the decision document with guidance on how to address other contaminants. If these additional contaminants are found in site soils at problematic levels, they will not respond to soil vapor extraction and constitute a deviation for which a contingency plan will be required.

2.3 The Selected Response Technology

The decision document contains numerous passages that identify the selected response technology and constrain the options available to the design team. Initially, the selected technology is identified in Paragraph 1.0(a) as pump and treat with UV/oxidation and soil vapor extraction with catalytic oxidation:

1.0(a) *Based on the requirements of CERCLA, the detailed analysis of the alternatives, and public comments, [the owner/operator and regulatory entities] have determined that Alternative No. 1 for ground water (pumping and surface treatment by UV/oxidation and air stripping), and Alternative No. 5 for the unsaturated zone (soil vapor extraction with catalytic oxidation of the extracted vapors) are the most appropriate responses for the site.*

In the case of the ground water response, subsequent text adds significantly to the specifications. Paragraphs 1.1(b) and 1.1(c) identify the approximate number of extraction wells to be installed (18), the approximate total extraction rate (350 gpm), the criteria for determining where wells are required (areas where VOCs or FHCs exceed 100 ppb and spacing that ensures hydraulic capture), the number of treatment facilities (7), the general location of treatment facilities (onsite as depicted in Figure 7 of the decision document) and the unit processes to be available at each treatment facility (UV/oxidation, air stripping, GAC and ion exchange as identified for each facility).

1.1(b) *The selected ground water response involves immediately pumping water at approximately 18 initial locations within the ground water plume (Figure 12). The total rate of ground water removal for this extraction plan is estimated to be about 350 gpm. Water will be pumped from one or more wells at each of these locations using existing monitor and extraction wells, along with new extraction wells. The well locations will be chosen to prevent any VOCs from escaping from the area in concentrations above their MCLs. To enable more rapid restoration, wells will also be placed in all areas where VOC or FHC concentrations in ground water exceed 100 ppb. Additional extraction locations may be added to ensure complete hydraulic capture of the plume, and/or to expedite cleanup if field data indicate additional wells are necessary.*

***1.1(c)** <u>Seven onsite facilities (A to G) will be constructed initially to treat the extracted ground water (Figure 12)</u>. Each treatment facility will be designed to treat a somewhat different combination of compounds. <u>Treatment facilities A, B, E, and F will use UV/oxidation as the primary treatment technology. Treatment Facilities C, D, and G will use air stripping as the primary treatment technology. Al facilities will use GAC to remove VOCs and FHCs from air streams, and Treatment Facility F will use GAC to remove lead from ground water. Treatment Facility D will use ion exchange to remove chromium from ground water</u>.*

As written, there is no mention of treatment or management options for tritium. Based on current technology, it is presumed that the tritium is to be managed through dilution, but the core team needs to establish some guidance on acceptable approaches for water that exceeds tritium MCLs. The text is also silent on disposal of treated water. Alternatives would include reinjection and discharge.

The specifications for the soil response are less specific than those for the ground water. <u>Paragraph 1.2(a)</u> identifies soil vapor extraction with catalytic oxidation of the extracted vapors as the technology to be implemented. <u>Paragraph 1.2(b)</u> restricts the extraction to wells as opposed to trenches or surface hoods. <u>Paragraph 1.2(c)</u> opens the door to use of additional or alternate unit processes if catalytic oxidation can not meet air emission requirements.

***1.2(a)** <u>The selected remedy for the unsaturated zone involves using soil vapor extraction to extract contaminant vapors under pressure from the unsaturated sediments and treating the vapors by catalytic oxidation</u>. Use of a catalytic oxidizer provides the flexibility to treat both FHCs and VOCs together and substantially reduces the potential for producing dioxin. The purpose of this response action is to prevent migration of VOCs and FHCs to ground water in concentrations that would impact the ground water in concentrations above MCLs.*

***1.2(b)** Current data indicate that only FHCs in the Gasoline Spill Area, VOCs in the Building A Area in the southeastern part of the site, and possibly VOCs in the vicinity of the laydown yard will need unsaturated zone response. <u>FHCs and/or VOCs will be removed from the subsurface by soil vapor extraction using extraction wells</u>.*

***1.2(c)** The selected treatment option for the extracted vapors is catalytic oxidation. In the process, vapors from extraction wells will be heated and passed through a catalyst, where organic compounds are converted to harmless oxidation products, including carbon dioxide and water. <u>If use of catalytic oxidation should result in emission of vapors with compounds above regulatory standards, secondary treatment or alternative technologies, such as GAC, will be evaluated and implemented to comply with regulatory standards.</u>*

The brevity of the text on the soil response leaves a great deal of flexibility to the design team unless the core team opts to add constraints. As written, the decision document is silent on numbers and location of extraction wells other than their probable need to be placed in the Gasoline Spill Area, the Building A Area, and near the laydown yard. At that, the ultimate decision rests with results of a modeling effort using an unspecified code to determine which soils threaten to raise ground water concentrations above MCLs for VOCs and FHCs. Pumping rates and vacuum levels are not specified. Even the selection of the vapor treatment technology is left open to further evaluation. The intent is that catalytic oxidation will be used if it can comply with air emission requirements. If emission requirements can not be met, add-on or alternate technologies can be utilized.

2.4 The Required End State

The required end state for the ground water is not clearly defined in this decision document. The most direct statement occurs in Paragraph 1.1(a) in conjunction with the response objective wherein it is declared that after cleanup, ground water will be below the MCLs:

1.1(a) *The primary purpose of the selected ground water remedy is to contain VOCs and prevent further downgradient and offsite migration in ground water, and to reduce the concentration of contaminants in ground water after cleanup to levels below MCLs, the designated cleanup levels. Existing conditions at the site may pose an excess lifetime cancer risk of 2 x 10-3 from ingestion of ground water contaminated with VOCs (primarily TCE) under health-conservative no response assumptions. The selected alternative will address all ground water contaminated with VOCs in excess of 5 ppb and will assure that ARARs for individual VOCs, FHCs, lead, chromium, and tritium will be achieved.*

This limited definition leaves a lot to interpretation such as what is an adequate demonstration of the fact that ground water is below MCLs. Ideally, the end state description would specify the number and location of samples, and the number of sampling events to verify the end state has been reached. The identity of the end state is further confused byParagraph 1.1(d) to the extent that it sets no criteria by which the regulators will evaluate if cleanup is complete:

1.1(d) *To ensure that cleanup levels continue to be maintained, the ground water will be monitored until the regulatory authorities agree that cleanup is complete.*

Given the lack of specificity on the end state, the core team will need to supplement this decision document with a more detailed definition for ground water. The situation is a little less nebulous for the soil response. Paragraph 1.2(d) defines the end state for soil as the point at which soil concentrations fall below the threshold that the site model indicates would threaten to raise ground water concentrations above MCLs:

1.2(d) *The decision regarding whether an area requires vadose cleanup will be based on unsaturated zone modeling and ground water monitoring. If modeling indicates that hazardous materials will impact ground water in concentrations above MCLs, response will be implemented. Response will continue until in situ concentrations, as verified by soil sampling, are below those predicted to impact ground water above MCLs. In addition, the ground water* *near the potential source will be monitored for impacts on ground water quality. Details of the modeling and monitoring will be presented in the design package.*

There is still room for interpretation in this definition. The core team may decide to constrain the model codes that would be acceptable for predicting ground water impacts. It is also unclear how the soil sampling will be performed (sample soil itself or soil vapor) and the number and locations of samples that would be considered representative of the source area.

2.5 Other Requirements

There are no other requirements in this decision document. The authors appear to be using ARARs and MCLs interchangeably as evidenced in Paragraphs 1.0(c), 1.1(a) and (b), and 1.2(a) and (d):

1.0(c) *The goal of this response is to remediate ground water to the ARARs specified in the PRAP and the decision document. Based on information obtained during the site investigation and on careful analysis of all alternatives, [the decision making authorities] believe that the selected response will achieve this goal. The approach to be taken will involve close monitoring of ground water quality in monitoring wells, extracted water quality in extraction wells, and water level elevations near extraction centers. The extraction well field will be operated dynamically to optimize the cleanup. That is, based on the results from the monitoring plan, individual wells may operate continuously, may be turned off, or may be pumped intermittently. During the course of the response, new wells will be installed at appropriate locations and will be operated in the same manner.*

1.1(a) *The primary purpose of the selected ground water remedy is to contain VOCs and prevent further downgradient and offsite migration in ground water, and to reduce the concentration of contaminants in ground water after cleanup to levels below MCLs, the designated cleanup levels. Existing conditions at the site may pose an excess lifetime cancer risk of 2 x 10-3 from ingestion of ground water contaminated with VOCs (primarily TCE) under health-conservative no response assumptions. The selected alternative will address all ground water contaminated with VOCs in excess of 5 ppb and will assure that ARARs for individual VOCs, FHCs, lead, chromium, and tritium will be achieved.*

1.1(b) *The selected ground water response involves immediately pumping water at approximately 18 initial locations within the ground water plume (Figure 12). The total rate of ground water removal for this extraction plan is estimated to be about 350 gpm. Water will be pumped from one or more wells at each of these locations using existing monitor and extraction wells, along with new extraction wells. The well locations will be chosen to prevent any VOCs from escaping from the area in concentrations above their MCLs. To enable more rapid restoration, wells will also be placed in all areas where VOC or FHC concentrations in ground water exceed 100 ppb. Additional extraction locations may be added to ensure complete* *hydraulic capture of the plume, and/or to expedite cleanup if field data indicate additional wells are necessary.*

1.2(a) *The selected remedy for the unsaturated zone involves using soil vapor extraction to extract contaminant vapors under pressure from the unsaturated sediments and treating the vapors by catalytic oxidation. Use of a catalytic oxidizer provides the flexibility to treat both FHCs and VOCs together and substantially reduces the potential for producing dioxin. <u>The purpose of this response action is to prevent migration of VOCs and FHCs to ground water in concentrations that would impact the ground water in concentrations above MCLs.</u>*

1.2(d) *The decision regarding whether an area requires vadose cleanup will be based on unsaturated zone modeling and ground water monitoring. <u>If modeling indicates that hazardous materials will impact ground water in concentrations above MCL, response will be implemented. Response will continue until in situ concentrations, as verified by soil sampling, are below those predicted to impact ground water above MCLs.</u> In addition, the ground water near the potential source will be monitored for impacts on ground water quality. Details of the modeling and monitoring will be presented in the design package.*

Had there been other ARARs that would need to be addressed, the decision document would have had a specific section identifying them. However, in light of the need to meet ARARs, it would be prudent for the core team to either reaffirm the lack of other ARARs or identify those that the design team need take into consideration.

It should be noted that while a performance measurement system is not specified, the document does identify certain minimum monitoring requirements. From <u>Paragraph 1.0(c)</u>, it is clear that at a minimum, performance measurement will include monitoring ground water quality in dedicated monitoring wells, monitoring the quality of extracted water, and monitoring the piezometric head surface of the aquifer.

1.0(c) *The goal of this response is to remediate ground water to the ARARs specified in the PRAP and the decision document. Based on information obtained during the site investigation and on careful analysis of all alternatives, [the decision making authorities] believe that the selected response will achieve this goal. <u>The approach to be taken will involve close monitoring of ground water quality in monitoring wells, extracted water quality in extraction wells, and water level elevations near extraction centers</u>. The extraction well field will be operated dynamically to optimize the cleanup. That is, based on the results from the monitoring plan, individual wells may operate continuously, may be turned off, or may be pumped intermittently. During the course of the response, new wells will be installed at appropriate locations and will be operated in the same manner*

2.6 Allowances

It should be clear from the analysis of this decision document that the required elements allow flexibility in how the response is designed. In addition, there are other areas that were identified for the design team and operators to optimize on the basis of best judgement. Areas of allowances include:

- *Paragraph 1.0(c)* - other means of performance measurement such as treatment efficiency
    - location, frequency and method of conducting required monitoring
    - decision logic for when and how to operate individual wells
    - decision logic for when and where additional wells will be installed
- *Paragraph 1.0(d)* - decision logic by which closure will be determined
- *Paragraph 1.1(a)* - approach to water with <5 ppb VOCs, but >MCLs for other contaminants
- *Paragraph 1.1(b)* - the exact number of initial wells and the final number of total wells
    - the total required extraction rate for ground water
    - the identity and number of new and existing wells to be utilized
    - decision criteria for when an area with > 100 ppb VOCs requires its own well
    - how complete hydraulic capture will be defined
    - decision criteria for what constitutes evidence that additional wells are necessary
- *Paragraph 1.1(c)* - means for addressing tritium
    - contingency for addressing arrival of contaminants not treated by the suite of processes scheduled for a given treatment facility
    - suite of analyses required for monitoring extracted water at each treatment facility.
    - means of discharging treated water
- *Paragraph 1.1(d)* - specific threshold to which risks should be compared
- *Paragraph 1.2(a)* - the means by which oxidation by-products such as hydrogen chloride are to be managed
- *Paragraph 1.2(b)* - selection between open and sealed surface design, air inlets and other enhancements
- *Paragraph 1.2(c)* - decision logic for selection of secondary or alternate off-gas treatment technology
- *Paragraph 1.2(d)* - identity of code to be applied for determining soil threshold concentrations
    - scenario to be modeled in determining soil thresholds
    - nature of accounting for rebound in soil contamination
    - nature, frequency and location of soil sampling
    - decision logic for evaluating ground water monitoring data near sources

The core team can elect to reduce the number and nature of allowances by superimposing additional constraints on the design team or can pass these allowances on to maximize the opportunity for innovative design. To the extent that areas of flexibility are left to the design team, the core team may choose to highlight specific areas where they wish to encourage creativity that is likely to reduce time and schedule requirements.

Appendix B: Contract Types

Basically there are three main types of contracts; fixed price, fixed unit price and cost plus and two main types of contractor selection methods; sole source and a competitive bid. In addition there are variations to these basic types that the project manager and procurement support personnel may deem most appropriate for the activity at hand. Below is a very cursory introduction to the main contract types and selection methods in order to give the reader some familiarity with the terms and advantages/disadvantages of each. Because Government procurement regulations are dynamic the reader is encouraged to take advantage of the local procurement office for additional sources of information in this area.

Contracting Options

Fixed Price: Fixed price contracts are awarded for a very specific scope of work, for a specified length of time and for a specific price. There should be little or no uncertainty in the activities covered by the contract. In order to proceed with a fixed price contract the project must be able to describe the work in sufficient detail to assure that all parties are estimating the same scope of work.

The advantage of a fixed price contract is that the uncertainty to the Government of the schedule and cost of a specific scope of work is greatly reduced. The disadvantages are that any efficiencies realized during the execution of the contract are the property of the contractor and not shared with the Government. In addition the Government is usually in a weaker bargaining position if changes or contract modifications are necessary.

Fixed Unit Price: Fixed unit price contracts are very similar to fixed price contracts except the quantity of work does not have to be explicitly determined. In these types of contracts the price is usually for the processing of a given quantity of material; i.e. excavating a cubic yard of soil, solidifying a cubic yard of waste, pumping and treating a gallon of contaminated water, etc. Typically a price will be established for a quantity range and if the actual quantities fall outside that range an alternate pricing schedule will govern or be negotiated.

Except for the variability of quantities, the scope of the work should be to the same level of detail as a fixed price contract. The advantages and disadvantages are also similar.

Cost Plus: Cost plus contracts obligate the Government to pay the contractors actual costs incurred for performing the work plus a fee. The fee can be either fixed or based on some award/ performance/incentive criteria. Fixed fees are calculated before the work is initiated and are usually determined as a percentage of the dollar value of the work that is expected to be performed. Procurement regulations govern the fee percentages that can be applied based on the type of work being performed.

Award / performance / incentive fees are all similar in that specific criteria and fee are established before the contract execution and if the contractor meets the criteria it also earns the associated fee. Examples of these criteria are that if a specific milestone is completed by a specific date a certain fee percentage will be paid or if a given activity is completed under an agreed to budget the contractor and Government will share the savings in some predetermined manner.

The advantage of a cost plus contract is that the scope of work does not have to be documented to the degree of detail that is required in fixed/fixed unit price contracts and change and redirection of the work can be effected at a minimal cost to the Government. Also the Government should benefit from any unplanned efficiencies realized during the performance of the work. The disadvantages are that there is little if any cost and schedule protection for the Government. Also the award / performance / incentive fee contracts must be carefully worded to assure the contractor works diligently toward all requirements and not just those that earn the fee.

It should be recognized that, for a variety of reasons it is unlikely that all of the work will be performed under subcontracts to the prime contractor. Because of time constraints, the necessity of maintaining a skilled workforce, etc. some of the work will be performed by the prime contractor and not subcontracted at all.

Contractor Selection

Sole Source: Sole source contractor selections occur when it has been determined, without competition, that one contractor is uniquely qualified to provide the service desired. This determination might be the result of an unsolicited proposal from a hopeful contractor or based on the knowledge of those responsible for the ultimate completion of the activity.

Sole source selections must be rigorously justified and are governed by numerous procurement regulations.

Competitive Bids: The competitive bid contractor selection process usually takes one of three forms; technical merits, price or a combination of the two.

- Technical Merits: Under the technical merit method of contractor selection a Request for Proposals (RFP) is issued that includes a detailed Statement of Work (SOW) for the proposed contract. The RFP is usually fairly explicit in identifying the format for the proposals in order to facilitate the evaluation process. Potential contractors submit their best technical proposal for performing the work. An evaluation panel evaluates each proposal against pre-established criteria and selects the most qualified contractor for the work. After the most qualified proposal is selected, a negotiation process takes place to establish the contract price.

  Contracts awarded on the basis of technical merits can be either fixed price, fixed unit price or cost plus contracts. They also are usually service contracts such as construction management, detailed design, etc.

- Price: Contracts awarded solely on the basis of price are usually of the fixed price or fixed unit price type. A request for bids is issued to potential bidders with a detailed SOW, usually a set of drawings and specifications. The contract is then awarded to the qualified bidder with the lowest bid price.

- Combination of Technical Merits and Price:It is not unusual to award contracts on the basis of both technical merits and price. This process entails selecting the two (or more) most qualified proposals and then using price to select the successful contractor.

Unique contracting strategies have also been developed to overcome many of the disadvantages identified above. For instance, one site has awarded multiple contracts for a generic scope of work. As specific activities are identified the SOW is provided to all qualified contractors with the available manpower to perform the work for a proposal. The contractor whose proposal is most advantageous to the Government (either based on technical merit, price or both) is then awarded the activity.

It is important to reiterate that the above is only a cursory introduction to the types of contracts and methods of contractor selection that are available to the Government and its prime contractors. There are numerous variations, combinations, nuances, and permutations to all of the above that make procurement representation on the core team invaluable.

Appendix C: Factors Affecting Procurement Approach

Complexity

Activities may range from the very simple (excavate and haul to burial ground) to the very complex (multi-component soil / water treatment system). During the early stages of a project (investigation and assessment), complexity may exist because the selected remedy itself is involved and difficult and/or is inherently present because many of the details of the response have not been resolved yet through the natural evolutionary process of a project. For these reasons, on complex activities, it is difficult to prepare a clear, well defined scope of work for the design phases and therefore difficult to perform these phases under fixed price contracting conditions. However, no matter how complex, if an activity can be well defined (e.g. drawings and specifications for a remedial action), it can be contracted using a fixed price contract.

Certainty / Uncertainty

This factor relates to the extent of information that is known about the project and is probably the most dominant determinant in the selection of the type of contract that will be used to perform the activity. If there is a high degree of confidence in all the information that was used to scope out an activity, the project manager has the complete range of contract types (fixed price to use of the prime contractors work force) available to satisfy the objective. In this instance there is a high degree of confidence that all the contaminants have been identified, the extent of contamination (area and depth) is known and treatment / disposition of the contaminants is technically feasible and has been agreed to by all project participants.

In the event there is a high degree of certainty in all aspects of a problem with the exception of quantities (e.g., what is the lateral / depth of contamination, how much groundwater is contaminated) all contract options are probably still available to the project manager with the exception of the fixed price contract.

As a project matures, the certainties increase and the uncertainties decrease. Therefore in the early stages of a project few of the activities may lend themselves to fixed/fixed unit price contracting while in the latter stages these contracting mechanisms may be most appropriate . Generally if there is a considerable amount of uncertainty in an activity, the scope of the contract will be difficult to define and, therefore, not suited for a fixed price or fixed unit price contract.

Scope

Scope in this context refers to the degree of control the contractor has over project activities. Some contracts limit the contractor to providing only those goods and services delineated in detail in the contract. These types of contracts are well suited to fixed price contracting modes with the contractor selected solely on price.

Other contracts provide the contractor with a specific end point that is desired and allow the contractor the flexibility to design and construct a process/facility that will achieve that end point. These contracts are mostly of the fixed price or cost plus variety and may very well lend themselves to some type of cost plus incentive sharing arrangement where both the contractor and the Government can share in the benefits. Contractor selection should definitely include an evaluation of technical qualifications.

Schedule

One of the most common forms of schedule influence is that legally binding milestones may not allow enough time for the procurement process with the result that the prime contractor performs the activity with on-site labor. In this respect, fixed price contracts usually require more time to place because the contract must be very detailed and more thoroughly reviewed to assure there are no discrepancies and inconsistencies that would entail costly modifications after contract award. Cost plus type contracts provide the project with some flexibility to fast track the work (start remedial action prior to completion of remedial design).

Interfaces

Generally the more interfaces a project or activity must contend with, whether they are contractual, organizational, or physical, the degree of uncertainty will be higher. Contractual interfaces are especially onerous in that any delays/non-performances on the part of one contractor could have major affects on another contractor. Much of the time the Government ends up being responsible for any schedule delays and/or added costs to the affected contractor.

Organizational and physical interfaces will most likely be less of a determining factor than contractual interfaces but are still of sufficient importance that the project manager should be cognizant of their potential when developing a procurement strategy. The more organizations involved, the more likely elements of the remedial design and implementation will not proceed as planned. Coordination of activities becomes more involved, review and approval times take longer as the number of affected parties increases, procedures may conflict, etc.

Examples of physical interfaces that could cause uncertainty for a given project or activity include working on or around existing structures under construction by another contractor and in a constant state of flux or using a disposal/borrow pit under the control of another entity. As the number of these interfaces increase so too does the uncertainty associated with an activity.

The core team must be cognizant of the potential affects of the interfaces when developing a procurement strategy.

Other

In addition to the factors identified above, a contracting strategy may also be influenced by external conditions. Procurement goals flowing down from HQ, the Program Office, the DOE site office, or the project manager may cause the core team to carve out pieces of work to satisfy goals such as a certain amount of fixed price contracting, a certain amount set-aside for small businesses, etc. Budgets (or lack thereof) may also influence procurement strategy. Fixed price contracts generally require that funds be committed for the entire contract at the time the contract is placed. If the contract is for a time period that spans more than one fiscal year the funds for the outyear(s) may not be available for this commitment. Although contractual provisions such as phased funding may still allow fixed price contracting under these conditions, the uncertainty of how much funding will be available in the following years for all Environmental Restoration activities may still preclude taking advantage of these provisions.

Appendix D: Incentive Clauses and Examples

* Note: This Appendix will be expanded further when more information becomes available

Government Incentive Clauses

Two examples of clauses that exist in the Federal Acquisition Regulations that can be used to incentivize implementation contracts are the Liquidated Damages Clause and the Value Engineering Clause. The liquidated damages clause mainly provides schedule incentives with the value engineering clause providing cost incentives. Example abbreviated clauses from the FAR are as follows:

- Liquidated Damages: If the contractor fails to complete the work within the time specified in the contract, or any extension, the contractor shall pay the Government as liquidated damages, the sum of X for each day of delay.

- Value Engineering: The contractor is encouraged to develop, prepare, and submit value engineering change proposals voluntarily. If a proposal is accepted, the contractor shall share in any net acquisition savings realized in accordance with a percentage determined by the type of contract (fixed price, cost-reimbursement) and or other arrangements specified in the contract. Typical percentages are 50% for fixed price contracts and 25% for cost-reimbursement contracts.

Private Sector Incentive Examples

The following are examples of various methods used in the private sector to provide incentives for contractors to align their goals with the owners goals.

- Purely Subjective: A contractor is paid periodically for costs with a bonus or penalty assessed based solely on the owners subjective evaluation of the contractors performance;

- Target Goals: Budgets and schedules are established for the work. The contractor receives X% of any cost under runs and a similar percentage for the value to the owner of the benefit of completing the job ahead of the target schedule.

- Industry Comparison: Performance goals are established based on industry averages. The contractors fee is based upon the degree to which the goals are met; and

- Detailed Evaluation: None or a portion of the fee is established as fixed. The remaining fee is assessed to various activities (engineering, contract management, construction, testing, etc.). A detailed evaluation (subjective, objective, or a combination of both) is then performed periodically. Fees are then awarded based upon a predetermined schedule.

Appendix E: Design Basis for Common Responses

E.1: SOIL--IN-SITU BIOREMEDIATION

Design Basis Elements

- Contaminant concentrations to determine nutrient requirements and period of performance (high contaminant concentrations can inhibit biodegradation, very low contaminant concentrations may not support biological activity; range of favorable concentrations varies by contaminant and site)
- Contaminant type to determine applicability and interferences (Kows greater than 1,000 are strongly sorbed to soil organic carbon and are less bioavailable)
- Contaminant types to determine oxygen needs (nonhalogenated aromatics, polynuclear aromatics, and nonhalogenated polar and nonpolar organics, generally are biodegraded more rapidly under aerobic conditions, certain halogenated aliphatics, halogenated aromatics, and polychlorinated biphenyls (PCBs) are more readily degraded anaerobically)
- Metals and radionuclides (generally not applicable)
- Multiple contaminants (presence of other contaminants; easily degradable contaminants will degrade first while more recalcitrant are left undegraded)
- Depth and areal extent of contamination (injection of nutrients is limited by drill-rig depth capabilities)
- Nutrient requirements (Nutrients that must be available in sufficient quantities for bioremediation to occur include C, H, O N, P, S, K, Ca, Fe, Mg, and Mn)
- Redox conditions (bioremediation can take place under aerobic or anaerobic conditions; aerobic biodegradation requires oxygen as the terminal electron acceptor (TEA) while anaerobic biodegradation uses TEAs such as NO_3^-, SO_4^{2-}, CO_2, Fe^{3+}, Mn^{4+}, oxygenated organics, and halogenated compounds)
- Rate-limiting nutrients (nitrogen and/or phosphorus are most frequently the rate-limiting nutrients in soil and are added to promote biodegradation, deficiencies of other nutrients are rare but should not be ignored)
- Bioaugmentation (soils typically contain the necessary soil bacterial communities to degrade contaminants; microbial additions may be desirable if the native community lacks the necessary bacteria to degrade the target compounds)
- Treatability tests (normally used to support remedy screening, selection, or design and to quantify biodegradation rates)
- Chemical and biological properties (COD and BOD are required to determine whether environmental conditions are conducive to microbial activity)
- Nutrient ratios (optimum carbon:nitrogen:phosphorus ratio is approximately 120:10:1; ratio is required to determine the need for additional nutrients)
- Oxygen (for an aerobic system require a minimum air-filled pore space of about 10 percent and soil gas oxygen concentrations greater than 5 percent)
- Temperature (generally, temperature should be in the range of 10 to 70 degrees C for bioremediation to proceed)
- Moisture content (moisture contents < 40 percent of field capacity limit biological activity; moisture contents > 80 percent of field capacity reduce oxygen availability in soil)

- Soil physical characteristics (clay content greater than 10 percent may limit contaminant bioavailability and reduce biodegradation kinetics)
- Soil chemical characteristics (pH outside range of 4.5 to 8.5 limits biological activity)
- Soil organic carbon (SOC) content (high SOC content may limit contaminant bioavailability and reduce biodegradation kinetics)
- Site accessibility (helps determine maximum size of equipment)
- Presence of cultural resources/artifacts

General Implementation Considerations

- Process monitoring requirements (continuous monitoring is necessary to ensure that the appropriate ratios of nutrients are maintained)
- Regulatory requirements (faults, flood plains, artifacts, wetlands, wildlife refuge, etc.)
- Security requirements

E.2: SOIL--IN-SITU STABILIZATION

Design Basis Elements

- Depth and areal extent of contamination to determine volume requirements and limitations (in-situ mixing is limited by equipment torque capabilities; in-situ injection is limited by drill-rig depth capabilities)
- Depth of freezing (freeze/thaw cycles may impact efficacy of stabilization; stabilization mixtures above the freeze line may require special formulations)
- Depth of water table (contaminants located below the water table may require soil dewatering prior to stabilization)
- Soil temperatures (low temperatures (less than 5°C) may impede solidification process and result in substandard solidification products)
- Contaminant types (limited effectiveness for organic compounds, primarily suited to inorganic compounds e.g., metals, radionuclides)
- Contaminant concentrations (soils containing more than a few percent organic material may be difficult to stabilize and require special additives and/or increased quantities of stabilization agent)
- Contaminant volatility (additional safety precautions and or containment may be required due to contaminant volatilization caused by reagent heat of hydration)
- Radionuclide concentrations (cuttings brought to the surface may require measures to reduce and control worker risk)
- Soil physical characteristics (soil particle-size distribution, hydraulic conductivity, moisture content, plasticity, shear strength etc. are required to size equipment (auger size, power requirements, etc.) and select solidification reagents and estimate volumes and composition)
- Soil chemical characteristics (low pH soils may require neutralization prior to treatment with cement solidification reagents)
- Treatability study (normally used to determine appropriate solidification agents and mixing ratios, includes leaching data on treated and untreated soils to determine extent to which contaminant mobility is reduced)
- Site accessibility (helps determine maximum size of equipment)
- Space availability (technology has relatively large space requirements for equipment operations and material stockpiling)
- Surface structures (buildings etc., may prevent equipment access to site, angled or horizontal drilling with mixing has not been demonstrated)
- Post remediation options (may limit disposal and treatment options)
- Natural and waste debris (boulders, trees, buried drums and tanks can impede auger advancement)
- Contaminant/Reagent compatibility (sulfates, borates, or organic materials may interfere with the effectiveness of cementitious and pozzolanic reagents)
- Means of introducing reagent
- Reaction time
- Product stability (structural properties , chemical leachability, estimated life)
- Presence of cultural resources/artifacts

General Implementation Considerations

- Process monitoring requirements (continuous monitoring is necessary to ensure that the appropriate ratios of stabilizing agent to contaminated soil are maintained)
- Volume increases (volume increases due to addition of stabilization agent may impact final site grading)
- Regulatory requirements
- Security requirements
- Final closure (may require cap to limit infiltration and contaminant migration)
- Maintenance and monitoring (may require groundwater monitoring and post closure care of cap etc.)

E.3: SOIL--IN-SITU VITRIFICATION

Design Basis Elements

- Depth and areal extent of contamination to determine staging and limitations (maximum demonstrated melt depth is approximately 20 feet, dictates electrode placement and enhancement techniques)
- Volume reduction/backfill availability (typically 20 to 40% reduction in volume, will be necessary to backfill if it is desired to restore site to grade)
- Electrical requirements (3-phase, 12,500-13,800 V, 200 amps, special multiple-tap transformer that converts power to 2-phase and transforms it to required voltage)
- Type of contamination (organics containing sulfur, phosphorus, or halogens may generate acid gases requiring off-gas treatment, immiscible-phase organics may limit technology)
- Radionuclides (high Plutonium loading in soil may pose a criticality threat)
- Soil particle-size gradation and composition (must have 30% minimum SiO_2 and 1.4% minimum combined Na_2O and K_2O, additives may be required for certain soil types)
- Depth to groundwater (soil may need to be dewatered for high water tables and permeable soils prior to implementation)
- Location of underground structures(required to avoid electrical short circuits or damage to structures, heat protection may be required if structure is within 6 meters of melt zone)
- Treatability study (normally used to confirm that final product meets leachability requirements)
- Topography (equipment requires relatively flat topography (+/- 5% slope) within equipment staging area)
- Space availability (must have space for 3 full-size tractor trailers, power generation equipment (if required), and 17-meter wide off-gas collection hood)
- Metal concentration (should not exceed 5% of the melt weight material)
- Organic liquid content (should not exceed 1-7% depending on BTU value)
- Sealed containers (drums and tanks should be removed from area prior to treatment)
- Combustible solids (must be mixed with soil prior to treatment)
- Tritium (completely removed and released out stack)
- Radon, cesium, and other volatile and semi-volatile radionuclides (may present an exposure concern because of accumulation of off-gas system)
- Off-gas treatment requirements
- Electrode spacing
- Product stability (structural properties , chemical leachability, estimated life)
- Presence of cultural resources/artifacts

General Implementation Considerations

- Treated glass must meet TCLP requirement of RCRA
- Permitting/other legal requirements (if governing regulatory agency considers this incineration, a trial burn may be necessary)
- Security requirements

E.4: SOIL--SOIL VAPOR EXTRACTION

Design Basis Elements

- Depth of contaminated soil zone to determine extraction depth and limitations (when installing vent wells to depths < 10 feet a surface seal may be required to prevent drawing air from atmosphere instead of contaminated vadose zone)
- Areal extent of plume and access to install wells/piping system (buildings or utilities which may limit access)
- Presence/impact of underground utilities (do they act as preferential pathways, will they interfere with drilling/trenching/piping)
- Contaminant volatility (applicable to contaminants having vapor pressures greater than 0.5 mm Hg at ambient temperatures and dimensionless Henrys Law constants greater than 0.01)
- Soil permeability to determine radius of influence and flow rates (only applicable to permeable soils; soils with permeabilities to air flow exceeding 10^{-8} cm^2 [10^{-3} m/sec hydraulic conductivity] are commonly regarded as permeable)
- Soil moisture content (not applicable if liquid volume is equal to or greater than 90 percent of pore volume because air cannot be effectively transported through wet soils)
- Site uniformity (layers or abrupt changes is permeability limit effectiveness because air will move through more permeable areas and leave less permeable areas untreated)
- Site access for equipment (drilling, treatment plant)
- Depth to water table (only effective above water table; water table may have to be lowered if contamination extends below water table)
- Efficiency (up to 98 percent removal can be obtained, total removal not practical using this method)
- Soil organic carbon (high soil organic carbon contents limit its effectiveness)
- Removal times (ten days to three year time frames have been reported for maximum removal)
- Contaminant concentrations (required to determine removal rates and off-gas treatment needs)
- What type of surface seal is in place or can be used to prevent vertical short circuiting
- Soil character (site stratigraphy and porosity are required to determine radial influence and contaminant removal rates of wells)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, excavation, air permits)
- Volume of contaminated soil to be treated (number of wells, network of piping system)
- Air flow rate, layout of vent wells and pattern of soil air flushing through contaminated soil zone
- Pore volume flushing time for contaminated soil zone (volume of contaminated media divided by air extraction rate)
- Other properties affecting chemical removal (presence of NAPL, low permeability zones)
- Provision of suitable electric power for equipment (site electric service, capacity, transformers)

- Unit process steps for treatment (entrained liquid /condensate separation, heating for humidity control, contaminant removal, discharge)
- Treatability study (required during remedy screening and selection process to determine effectiveness)
- Combination of unit treatment processes (air extraction, conveyance, treatment, discharge, process control system)
- Residuals/waste streams generated (condensate water, chemicals removed in off-gas treatment system, discharge of treated air)
- Monitoring required (influent air stream, discharge air stream, flow rates and mass fluxes from wells)
- Handling of residuals(containerizing, labeling, storage)
- Disposal requirements (manifesting, transport & disposal of waste)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (condensate generation, freeze protection for any liquids generated)
- Operating procedures manual
- System optimization for maximum contaminant removal as conditions change
- Permitting/other legal requirements(applicable patents)
- Security requirements

E.5: SOIL--DIG AND TREAT WITH SOIL WASHING/SIZE SEPARATION

Design Basis Elements

- Depth of contamination (physical constraints of equipment, shoring requirements)
- Water table (Excavation of soils below the water table requires dewatering operations)
- Areal extent and access to excavate with equipment (buildings or above ground utilities which may limit access)
- Presence/impact of underground utilities (can utilities be shutdown and/or rerouted)
- Depth of contamination (treatable contamination depends on equipment and excavation technique; Draglines and backhoes can reach depths of 30-50 feet, clamshells can be used to 100 feet)
- Presence of cultural resources/artifacts
- Capacity (typically, 6-40 tons/hr of soil)
- Treatability studies (small-scale studies using site-specific soils and contaminants are the best way to predict effectiveness)
- Natural and waste debris (boulders, trees, and buried drums can impede site excavation)
- Contaminant properties (water solubility and chemical form are needed to help predict the contamination distribution in the Coarse and fine soil fractions)
- Types of contaminants (applicable to any contaminant retained in the fine-grained portion of the soil)
- Permits required (utility clearance, NPDES/Stormwater, excavation, air permits)
- Soil characteristics (clay soils may preclude use of soil separation because of limited volume reductions)
- Soil physical and chemical properties (particle size distribution, organic carbon content, and mineral composition needed to predict effectiveness, slope stability, etc.)
- Volume of soil to be treated (staging/storage areas required, throughput capacity of treatment process)
- Site access for equipment (excavation zone , staging area, treatment equipment, storage piles, backfill)
- Chemical characteristics of contaminants (low/high level radionuclides, mixed waste, metals, organics)
- Provision of suitable electric power for equipment (site electric service, capacity, transformers, portable generators)
- Unit process steps for treatment (initial screening, size separation, washing/separation vessels, filtering of wash liquor)
- Combination of unit treatment processes (materials handling/storage/movement through treatment steps)
- Residuals/waste streams generated (concentrated waste soil, wash liquor, filter material)
- Monitoring required (cleaned soil, concentrated waste soil, dust emissions, wash liquor)
- Handling of residuals(drumming, labeling, storage)
- Disposal requirements (manifesting, transport & disposal of waste)
- Restore site (backfill, recompaction, utility reconnect, resurfacing)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (freeze protection for process solutions, wind erosion protection for storage piles, runoff collection from storage piles)
- Fugitive dust emissions
- Operating procedures manual
- Permitting/other legal requirements
- Security requirements

E.6: SOIL--DIG AND TREAT STABILIZATION/SOLIDIFICATION

Design Basis Elements

- Depth of contamination (treatable contamination depends on equipment and excavation technique; Draglines and backhoes can reach depths of 30-50 feet, clamshells can be used to 100 feet)
- Removal rates (ranges from 5 - 400 yd^3/hr)
- Areal extent of contamination (larger excavations may require backhoes and draglines, clamshells are used for contamination that is narrow or of limited areal extent)
- Soil temperatures (low temperatures (less than 5^oC) may impede solidification process and result in substandard solidification products)
- Water table (Excavation of soils below the water table requires dewatering operations)
- Contaminant types (limited effectiveness for organic compounds, primarily suited to inorganic compounds e.g., metals, radionuclides)
- Contaminant concentrations (soils containing more than a few percent organic material may be difficult to stabilize and require special additives and/or increased quantities of stabilization agent)
- Contaminant volatility (additional safety precautions and or containment may be required due to contaminant volatilization caused by reagent heat of hydration)
- Radionuclide concentrations (excavated materials brought to the surface may require measures to reduce and control worker risk)
- Strength and/or other waste acceptance criteria (strength typically required to evaluate physical stability and handling characteristics. EPA recommends unconfined compressive strength, UCS, of 50 psi.)
- Leachability (TCLP is required to determine whether a waste is hazardous because of its leaching characteristics)
- Solidification reagent/waste ratio (cement to waste ratios typically vary from 1:5 to 1:1; lime/ waste ratios from 5:100 to 30:100 ; bitumen/thermoplastic resin to waste ratios vary from 1:2 to 1:1)
- Volume increases (typical volume increases of 20 to 50 percent result from mixing reagent with waste)
- Permeability (permeabilities of stabilized material higher than 10^{-5} cm/s are usually unacceptable)
- Soil characteristics (soil type and strength are required to evaluate the side and bottom stability and design slope protection)
- Soil physical characteristics (soil particle-size distribution is required to select solidification reagents and estimate volumes and composition)
- Soil chemical characteristics (low pH soils may require neutralization prior to treatment with cement solidification reagents)
- Bench-scale laboratory treatability study (usually performed to determine reagent/waste mix design)
- Obstructions (locations of utilities, structures, and other obstructions are required so that they can be avoided during excavation)

- Drums, debris, and tanks (special precautions are required when these items are present in the soil)
- Site accessibility (required to establish maximum size of equipment that can be used)
- Distance to treatment/disposal facility (needed to determine costs; increases in weight and volume from solidification process may render solidification uneconomical)
- Space availability (technology has relatively large space requirements for equipment operations and material stockpiling)
- Natural and waste debris (boulders, trees, buried drums and can impede site excavation)
- Contaminant/Reagent compatibility (sulfates, borates, or organic materials may interfere with the effectiveness of cementitious and pozzolanic reagents)
- Reaction time (curing time is required to estimate throughput)
- Product stability (structural properties , chemical leachability, estimated life)

General Implementation Considerations

- Process monitoring requirements (continuous monitoring is necessary to ensure that the appropriate ratios of stabilizing agent to contaminated soil are maintained)
- Slope protection may be required depending on excavation depth and soil type
- Fugitive dust emissions (must be controlled if site is near a populated area)
- Regulatory requirements
- Post remediation options (may limit disposal and treatment options)
- Security requirements
- Final closure (may require cap to limit infiltration and contaminant migration)
- Maintenance and monitoring (may require groundwater monitoring and post closure care of cap etc.)

E.7: SOIL--DIG AND TREAT - SOIL WASHING/CHEMICAL EXTRACTION

Design Basis Elements

- Depth of contamination (treatable contamination depends on equipment and excavation technique; Draglines and backhoes can reach depths of 30-50 feet, clamshells can be used to 100 feet)
- Volume of washing solution (usually 1-2 times volume of soil per washing step, several washing steps may be required depending on the removal efficiency of the washing solution and the desired residual levels in soils)
- Capacity (typically, 6 to 40 tons of soil per hour)
- Removal rates (ranges from 5 - 400 yd^3/hr)
- Types of contaminants (applicable to any contaminant that will partition into the wash solution, effectiveness is soil and contaminant specific)
- Areal extent of contamination (larger excavations may require backhoes and draglines, clamshells are used for contamination that is narrow or of limited areal extent)
- Water table (excavation of soils below the water table requires dewatering operations)
- Radionuclide concentrations (excavated materials brought to the surface may require measures to reduce and control worker risk)
- Bench-scale laboratory treatability study (small-scale studies usually conducted using site-specific soils and contaminants to determine effectiveness
- Contaminant properties (water solubility and chemical form are required to select washing reagents)
- Soil physical and chemical properties (needed to predict effectiveness and select equipment type and washing reagents)
- Soil volume (needed to size equipment)
- Obstructions (locations of utilities, structures, and other obstructions are required so that they can be avoided during excavation)
- Drums, debris, and tanks (special precautions are required when these items are present in the soil)
- Soil texture (clays may be hard to disperse which will increase reaction vessel size and washing time)
- Soil organic carbon content (high concentrations of organic carbon may decrease effectiveness because of adsorption of contaminants)
- Space availability (must be adequate for soil washing equipment and temporary storage of contaminated and washed soils)
- Natural and waste debris (boulders, trees, buried drums and can impede site excavation)
- Soil characteristics (clay soils may preclude the use of soil washing; soil minerals may act as buffers and preclude the use of washing solutions that rely on acids or bases)

General Implementation Considerations

- Process monitoring requirements (continuous monitoring is necessary to ensure that appropriate ratios of washing solution to contaminated soil are maintained and that desired removal efficiencies are obtained)
- Slope protection may be required depending on excavation depth and soil type
- Wash solution may require treatment before disposal
- Fugitive dust emissions (must be controlled if site is near a populated area)
- Regulatory requirements
- Security requirements

E.8: SOIL--DIG AND HAUL FOR DISPOSAL

Design Basis Elements

- Depth of contamination (physical constraints of equipment, shoring requirements, proximity to water table; draglines and backhoes (modified) can reach depths of 30-50 feet, clamshells can reach depths of 100 feet)
- Removal rates (ranges from 5-400 yd^3/hr)
- Areal extent and access to excavate with equipment (buildings or above ground utilities which may limit access)
- Obstructions (locations of underground utilities, structures must be noted so they can be avoided during excavation and utilities can be shutdown and/or rerouted)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, NPDES/Stormwater, excavation, air permits)
- Volume of soil to be excavated (staging/storage areas required)
- Drums, debris, and tanks (special precautions are required when these items are present in the soil)
- Site access for equipment (excavation zone , staging area, storage piles, backfill)
- Physical characteristics of media (slope stability of excavation sidewalls)
- Chemical characteristics of media (low/high level radionuclides, mixed waste, metals, organics)
- Residuals/waste streams generated (waste soil, runoff from storage piles)
- Natural and waste debris (boulders, trees, and buried drums can impede site excavation)
- Monitoring required (waste soil, dust emissions)
- Distance to treatment/disposal facility (needed to determine costs)
- Disposal requirements (manifesting, transport & disposal of waste)
- Restore site (backfill, recompaction, utility reconnect, resurfacing)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (wind erosion protection for storage piles, runoff collection from storage piles)
- Suitable access routes for trucks to disposal facility
- Permitting/other legal requirements
- Security requirements

E.9: SOIL--CAPPING

Design Basis Elements

- Areal extent of contaminated zone and access to cap (buildings or utilities which may limit access)
- Presence of cultural resources/artifacts
- Soil cover (usually range in thickness from 2-4 feet of compacted clay with permeabilities less than 10^{-7} cm/sec; should be placed below frost line)
- Flexible membranes (usually range in thickness from 20-100 mils; typically placed below frost layer)
- Slopes (top slope is usually from 3-5 percent after allowing for settling or subsidence)
- Contaminant characterization (required to assure that cap addresses all contaminant hazards e.g., thickness to mitigate radiation hazards)
- Erosion control (vegetative covers are used if climate will support them; if not, armored covers are used)
- Biointrusion layers (required when intrusion from burrowing animals is a problem; consists of large pebbles)
- Effectiveness (reduce infiltration for clay caps to 3 cm or less per year while more elaborate designs may reduce infiltration to 0.5 cm/year or less)
- Combined topsoil/native soil layer (combined thickness is the greater of 2 feet or the depth of frost penetration)
- Granular drainage layer (thicknesses range from 0.5 to 5 feet; may not be required if soil protective layer is adequate)
- Temperature fluctuations (large temperature fluctuations may cause cracking in synthetics because of a large coefficient of thermal expansion)
- Volatile gas generation (some wastes may generate gases that require venting through cap)
- Potential waste volume changes (changes in waste volume through settling or gas generation may affect waste performance; stabilization may be required to preclude problems with waste volumes)
- Local climate (wind speeds, precipitation data are needed to design cap and covers)
- Permits required (utility clearance, excavation, air permits)
- Surface structures (types and locations of surface structures are required to account for these structures in cap design)
- Adjacent sites (locations of adjacent sites are required to assure that runoff is properly managed and whether a single cap is desirable or if multiple caps are preferable)
- Runoff collection system from capped area

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Permitting/other legal requirements
- Security requirements, access restrictions after capped is placed
- Cap maintenance (long-term cap maintenance will be required; includes surface and perimeter monitoring)

E.10: SOIL--BIOVENTING

Design Basis Elements

- Depth of contaminated soil zone (vent well construction depths, screen intervals, shallow contamination or groundwater may preclude this technology because of diminished radius of influence and cheaper alternatives)
- Areal extent of plume and access to install wells/piping system (buildings or utilities which may limit access)
- Presence/impact of underground utilities (do they act as preferential pathways, will they interfere with drilling/trenching/piping)
- Types of contaminants (contaminants susceptible to aerobic biodegradation; not applicable to inorganic elements and compounds)
- Concentrations of contaminants (contaminant concentrations too high may inhibit biological activity while concentrations too low may not support biological activity)
- Contaminant source (should be eliminated to the extent possible before beginning bioventing)
- Presence of multiple contaminants (an easily degradable contaminant will be degraded first leaving behind more recalcitrant undegraded contaminants)
- Solubility (contaminants with aqueous solubility less than 1 mg/l are difficult to biodegrade)
- High hydrophobicity (contaminants with Kows greater than 1,000 are difficult to biodegrade because they are highly adsorbed to organic carbon and less available)
- Site access for equipment (drilling, treatment plant)
- Time to complete remediation (most economically-feasible systems achieve remediation in 1-3 years; may not be appropriate if a short (< 6 months) cleanup time is required)
- Soil permeability (with soils not very permeable to air flow (i.e., permeability < 10^{-11} cm^2) oxygen delivery and biodegradation rates will be low)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, excavation, air permits)
- Volume of contaminated soil to be treated (number of wells, network of piping system)
- Layout of vent wells and pattern of soil air flushing and oxygen delivery through contaminated soil zone
- Rate of oxygen delivery to contaminated soil zone
- Properties affecting biodegradation rate (moisture content, pH, other nutrients)
- Other properties affecting chemical degradation (presence of NAPL, low permeability zones)
- Physical characteristics of media (hydraulic conductivity of soil, radial influence of vent wells, pressure induced in vent wells)
- Chemical characteristics of media (low/high level radio nuclides, mixed waste, metals, organics)
- Provision of suitable electric power for equipment (site electric service, capacity, transformers)
- Unit process steps for treatment (air injection, monitoring)
- Monitoring required (air injection rates, 0_2 and $C0_2$ levels in soil gas)

- Handling of residuals(containerizing, labeling, storage)
- Disposal requirements (manifesting, transport & disposal of waste)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (condensate generation, freeze protection for any liquids generated)
- Operating procedures manual
- System optimization for maximum contaminant removal as conditions change
- Permitting/other legal requirements(applicable patents)
- Security requirements

E.11: GROUND WATER--PUMP AND TREAT

Design Basis Elements

- Depth of ground water plume (well construction depths, screen intervals, lift requirements for submersible pumps and type of system employed; suction-lift pumps are only effective to 15-20 feet)
- Areal extent and depth of contamination (required to determine number of wells, placement and design)
- Types of contaminants (determine removal rates, treatment type and discharge limitations)
- Presence/impact of underground utilities (do they act as preferential pathways, will they interfere with drilling/trenching/piping)
- Soil characteristics (porosity, organic carbon content, hydraulic conductivity, and grain-size distribution are required to determine how contaminant will partition between the aqueous and gaseous phases)
- Aquifer characterization (storativity, permeability, gradient, flow direction, and available drawdown required for good well design)
- Presence of other well fields or surface water bodies (to determine if drawdown in pumping wells will impact flow patterns of other wells and/or water levels)
- Site access for equipment (well drilling, treatment plant)
- Casing diameters (chosen to accommodate pump and prevent uphole water velocities greater than 1.5 m/sec; typical diameters range from 4-inch that can handle up to 200 gal/minute at 1.5 m/sec to 24-inch that can supply up to 6,500 gal/minute at 1.5 m/sec)
- Screens and open area (may range from 5 percent open area for high-strength screens with small openings to 75 percent for low-strength screens with large openings)
- Multiple aquifers (groundwater extraction from a single aquifer may have adverse effects because gradients created can cause contamination of other aquifers)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, excavation, air permits, NPDES, water resource use)
- Pore volume flushing time of contaminated ground water zone (plume volume divided by pumping rate)
- Hydraulic conductivity (soils with hydraulic conductivities less than 10^{-4} cm/sec are difficult to remediate because of a limited ability to extract water)
- Other properties affecting chemical removal (presence of NAPL, low permeability zones)
- Seasonal or intermittent pumping schedules of water use wells in the area
- Chemical characteristics of media (low/high level radio nuclides, mixed waste, metals, organics, presence of other water quality parameters [iron, calcite, etc.] which indicate potential for scale formation in piping/treatment equipment)
- Provision of suitable electric power for equipment (site electric service, capacity, transformers)
- Unit process steps for treatment (pretreatment, contaminant removal, polishing treatment)
- Combination of unit treatment processes (extraction, conveyance, treatment, discharge, process control system)
- Off-gas treatment requirements (air stream dehumidifying, carbon adsorption efficiency, oxidation system)

- Residuals/waste streams generated (chemicals removed, discharge of treated water)
- Monitoring required (influent water, treated water, contaminant waste stream)
- Handling of residuals (containerizing, labeling, storage)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (freeze protection for process solutions)
- Operating procedures manual
- Permitting/other legal requirements
- Security requirements

E.12: GROUND WATER--IN-WELL STRIPPING WITH RECIRCULATING WELLS

Design Basis Elements

- Depth of ground water plume (generally should be 10 feet or greater to provide sufficient space to recharge water; well construction depths, extraction and recharge screen intervals, submersion requirements for pumping)
- Areal extent and depth of plume and access to install wells/piping system (buildings or utilities which may limit access)
- Presence/impact of underground utilities (do they act as preferential pathways, will they interfere with drilling/trenching/piping)
- Stratigraphy (impervious layers between the vadose-zone discharge point and the water table will require specialized designs)
- Hydraulic conductivity (must be greater than 10^4 cm/sec to move sufficient water)
- Contaminant strippability (contaminant should have a Henrys Law constant greater than 5 X 10^{-4} atm-m^3/mole)
- Site access for equipment (well drilling, treatment plant)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, excavation, air permits)
- Plume volume of contaminated ground water to be treated (number of wells, network of piping system)
- Pore volume flushing time of contaminated ground water zone (plume volume divided by pumping rate)
- Properties controlling chemical desorption from soil (retardation of chemical movement/recovery in flushing calculations)
- Other properties affecting chemical removal (presence of NAPL, low permeability zones)
- Physical characteristics of media (possible presence of low permeability lenses in plume, hydraulic conductivity/yield of aquifer, treatment zone of recirculating wells, drawdown in pumping wells, grain-size distribution for screen and filterpack sizing)
- Chemical characteristics of media (low/high level radio nuclides, mixed waste, metals, organics, presence of other water quality parameters [iron, calcite, etc.] which indicate potential for scale formation in recharge zones)
- Provision of suitable electric power for equipment (site electric service, capacity, transformers)
- Off-gas treatment requirements (air stream dehumidifying, carbon adsorption efficiency, oxidation system)
- Residuals/waste streams generated (chemicals removed, condensate water collected)
- Monitoring required (influent water, treated water, off-gas air stream before and after treatment)
- Handling of residuals(containerizing, labeling, storage)
- Disposal requirements (manifesting, transport & disposal of waste)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (freeze protection for process streams)
- Operating procedures manual
- Permitting/other legal requirements (applicable patents for technology)
- Security requirements

E.13: GROUND WATER--DUAL-PHASE EXTRACTION

Design Basis Elements

- Depth of ground water plume (well construction depths, extraction intervals, vacuum and lift requirements for pumping)
- Areal extent of plume and access to install wells/piping system (buildings or utilities which may limit access)
- Presence/impact of underground utilities (do they act as preferential pathways, will they interfere with drilling/trenching/piping)
- Aquifer permeability (generally should be 10^{-4} cm/sec or lower so that water renters treatment zone slowly)
- Site access for equipment (well drilling, treatment plant)
- Types of contaminants (generally applicable to contaminants with Henrys Law constants greater than 2.5 X 10^{-4} atm.-m^3/mole or vapor pressures greater than 1 mm Hg. at ambient temperatures)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, excavation, air permits, NPDES, water resource use)
- Plume volume of contaminated ground water to be treated (number of wells, network of piping system)
- Pore volume flushing time of contaminated ground water zone (plume volume divided by pumping rate)
- Properties controlling chemical desorption from soil (retardation of chemical movement/recovery in flushing calculations)
- Other properties affecting chemical removal (presence of NAPL, low permeability zones)
- Physical characteristics of media (hydraulic conductivity/yield of aquifer, capture zone from extraction well, drawdown in pumping wells, grain-size distribution for screen and filterpack sizing)
- Chemical characteristics of media (low/high level radio nuclides, mixed waste, metals, organics, presence of other water quality parameters [iron, calcite, etc.] which indicate potential for scale formation in equipment)
- Provision of suitable electric power for equipment (site electric service, capacity, transformers)
- Unit process steps for treatment (liquid/gas phase separation, pretreatment, contaminant removal, polishing treatment)
- Combination of unit treatment processes (extraction, conveyance, treatment, discharge, process control system)
- Off-gas treatment requirements (air stream dehumidifying, carbon adsorption efficiency, oxidation system)
- Residuals/waste streams generated (chemicals removed, condensate water collected)
- Monitoring required (influent water, treated water, off-gas air stream before and after treatment)
- Handling of residuals(containerizing, labeling, storage)
- Disposal requirements (manifesting, transport & disposal of waste)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (freeze protection for process streams)
- Operating procedures manual
- Permitting/other legal requirements (applicable patents for technology)
- Security requirements

E.14: GROUND WATER--CONTAINMENT BARRIERS

Design Basis Elements

- Depth to bottom of ground water plume (total depth of barrier wall, presence of an aquitard to tie in base of barrier wall)
- Areal extent of plume and access to install barrier system (buildings or utilities which may limit access)
- Surface capping to prevent precipitation infiltration into contained area
- Presence/impact of underground utilities (will they interfere with barrier construction/installation, can they be shutdown/rerouted)
- Types of contaminants (applicable to all contaminants present in groundwater)
- Wall permeability (typical values for wall permeability range from 10^{-6} to 10^{-7} cm/sec)
- Wall thickness (24 - 48 inches is typical for slurry, soil mixed, and jetted wall)
- Slurry levels during construction (height of slurry wall should be maintained 2 to 4 feet above groundwater level to maintain trench stability)
- Backfill slope range (typical horizontal to vertical backfill slope ranges from 6:1 to 10:1)
- Site access for construction equipment (excavator, slurry mix area, driving hammer for sheet pile)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, excavation, NPDES/stormwater)
- Linear length and depth of barrier to be installed (total square feet of barrier required)
- Physical characteristics of the soil (grain-size distribution for slurry mix, blow counts and density for sheet pile)
- Chemical characteristics of contaminated ground water (compatibility with slurry wall, corrosion potential for sheet pile wall)
- Residuals/waste streams generated during construction (excavated soils)
- Protection from burrowing animals
- Slope and surface with respect to surface water runon and runoff
- Vegetative cover
- Water budget from contained/capped area
- Monitoring required (hydraulic head inside and outside of contained area, contaminant concentrations outside of contained area)
- Handling of residuals(containerizing, labeling, storage)
- Disposal requirements (manifesting, transport & disposal of waste)
- Restore site(backfill, recompaction, utility reconnect, resurfacing)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (wind erosion protection for storage piles, runoff collection from storage piles, difficulties in system construction in heavy precipitation)
- Permitting/other legal requirements
- Security requirements

E.15: GROUND WATER--IN-SITU PERMEABLE TREATMENT ZONE BARRIERS

Design Basis Elements

- Depth to bottom of ground water plume (total depth of barrier wall, presence of an aquitard to tie in base of barrier wall)
- Areal extent of plume and access to install barrier system (buildings or utilities which may limit access)
- Presence/impact of underground utilities (will they interfere with barrier construction/installation, can they be shutdown/rerouted)
- Site access for construction equipment (excavator, driving hammer for sheet pile)
- Presence of cultural resources/artifacts
- Permits required (utility clearance, excavation, NPDES/stormwater)
- Linear length, depth and thickness of barrier to be installed (total square feet and volume of barrier required)
- Physical characteristics of the aquifer and permeable media (travel time to and across permeable reaction zone)
- Chemical characteristics of contaminated ground water (plugging/fouling/precipitates)
- Installation as a funnel and gate approach or as a complete permeable barrier treatment wall (conceptual configuration and hence permeable cross section and flux rates)
- Groundwater flux through the barrier 9 required media permeability)
- Residence time in the barrier treatment zone (thickness and capacity of media)
- Chemistry of treatment/removal in the permeable segment (identify interferences and residency requirements)
- Life of the treatment media (determine need to replenish or regenerate media)
- Anticipated period of performance (determine capacity or regeneration requirements)
- Means of regenerating/replacing treatment media if relevant (logistics of regenerating media)
- Residuals/waste streams generated during construction(excavated soils)
- Monitoring required (contaminant concentrations upgradient and downgradient of permeable wall)
- Handling of residuals(containerizing, labeling, storage)
- Disposal requirements (manifesting, transport & disposal of waste)
- Restore site(backfill, recompaction, utility reconnect, resurfacing)

General Implementation Considerations

- H&S, PPE requirements for dealing with exposure potential (airborne dust, dermal contact, vapors)
- Weather related considerations (wind erosion protection for storage piles, runoff collection from storage piles)
- Permitting/other legal requirements (applicable patents for technology)
- Security requirements

E.16: GROUNDWATER--IN-SITU BIOREMEDIATION

Design Basis Elements

- Location (contaminant location in relation to ground surface and water table determines bioreclamation approach)
- Weather (infiltration rates may affect dissolved oxygen levels)
- Site hydrology (ability to deliver nutrients and terminal electron acceptors to contaminated subsurface zone is affected by permeability; minimum permeability should be > 10^{-3} cm/sec)
- Contaminant concentrations (high contaminant concentrations can inhibit biodegradation, very low contaminant concentrations may not support biological activity; range of favorable concentrations varies by contaminant and site)
- Particle-size distribution (extreme heterogeneity in soil particle-size distribution leads to inconsistent bioreclamation of contaminated media)
- Contaminant types (most frequently used to treat soil/water systems contaminated with gasoline, diesel, jet fuel, and BTEX. Cometabolic biodegradation of chlorinated aliphatic solvents has also been demonstrated)
- Contaminant types (certain halogenated aliphatics, halogenated aromatics, and polychlorinated biphenyls, or PCBs are more readily degraded anaerobically)
- Metals and radionuclides (generally not applicable)
- Multiple contaminants (presence of other contaminants; easily degradable contaminants will degrade first while more recalcitrant contaminants are left undegraded)
- Depth and areal extent of contamination (injection of nutrients is limited by drill-rig depth capabilities)
- Rate-limiting nutrients (nitrogen and/or phosphorus are most frequently the rate-limiting nutrients in soil and are added to promote biodegradation, deficiencies of other nutrients are rare but should not be ignored)
- Bioaugmentation (soils typically contain the necessary soil bacterial communities to degrade contaminants; microbial additions may be desirable if the native community lacks the necessary bacteria to degrade the target compounds)
- Substrate addition (adding substrates such as methane and phenol has been demonstrated effective for the aerobic oxidation of chlorinated solvents through cometabolism)
- Treatability tests (normally used to support remedy screening, selection, or design and to quantify biodegradation rates)
- Redox potential (redox potential greater than 50 mV for aerobic/facultative system; < 50mV for anaerobic system)
- Terminal electron acceptor (aerobic biodegradation requires oxygen as the terminal electron acceptor (TEA) while anaerobic biodegradation uses TEAs such as NO_3^-, SO_4^{2-}, CO_2, Fe^{3+}, Mn^{4+}, oxygenated organics, and halogenated compounds)
- Chemical and biological properties (COD and BOD are required to determine whether environmental conditions are conducive to microbial activity)
- Nutrient ratios (optimum carbon:nitrogen:phosphorus ratio is approximately 120:10:1; ratio is required to determine the need for additional nutrients)

- Oxygen (for an aerobic system, dissolved oxygen concentrations should be > than 1 mg/l; < 1 mg/l for an anaerobic system)
- Oxygen (may need to add hydrogen peroxide to injection system to increase oxygen concentrations; care is needed as hydrogen peroxide is toxic to bacteria at high concentrations. Hydrogen peroxide at 40 mg/l has been reported to provide sufficient oxygen without inhibiting bacterial growth)
- Temperature (generally, temperature should be in the range of 10 to 70 degrees C for bioremediation to proceed) biodegradation kinetics)
- Soil chemical characteristics (pH outside range of 4.5 to 8.5 limits biological activity)
- Soil organic carbon (SOC) content (required to determine sorption characteristics of aquifer soil which may impact contaminant bioavailability and mobility)

General Implementation Considerations

- Reinjected water augmented with nutrients, etc. (must be reinjected into the aquifer from which it was extracted and meet standards similar to surface water discharge standards if practicable.
- Process monitoring requirements (continuous monitoring is necessary to ensure that the appropriate ratios of nutrients are maintained)
- Regulatory requirements (faults, flood plains, artifacts, wetlands, wildlife refuge, etc.)
- Security requirements

Appendix F: Examples of Degrees of Premobilization of Contingencies

Level of Development	Conditions	Examples
Contingency identified, conceptual design only	• High cost of mobilization • Low probability of need • Incompatible with implementation of selected remedy • Delays associated with stoppage to mobilize contingency not critical to success of remedy	• Contamination extends under buildings so that entirely different approach to excavation is required • Response to pump and treat indicates probable existence of DNAPLs requiring physical containment with slurry walls
Contingency plan developed, but details not complete, no premobilization	• Moderate cost of mobilization and low probability of need • High cost of mobilization and moderate probability of need • Premobilization would disrupt implementation of selected remedy • Short term delays in mobilization would not raise cost or risk substantially	• Alternate treatment scheme designed in case unanticipated contaminants are encountered • Plans developed to reroute subsurface utilities if encountered during excavation • Alternate equipment located but not brought onsite in case site conditions will not accommodate required designs
Contingency fully developed and mobilized for seamless transition if required	• Low cost of mobilization • Higher probability of need • Premobilization has little or no effect on implementation of selected remedy • Time delays in mobilization could raise costs and/or risks significantly	• Prearranged contracts for offsite storage/disposal if excavated soil volume exceeds onsite capacity or if low level waste becomes radioactive mixed waste • Completed designs for surface seals and thermal enhancement should field conditions indicate short circuiting of soil vapor extraction system • Shoring materials available in case excavation is deeper than anticipated

Appendix G: Elements and Source of Completion/Closure Reports

Completion/Closure Report Element	Source
Problem statement	Scoping and decision document decision rules
Description of selected response	Decision document
Details of implementation	"As builts," notice of modifications
Contingencies executed	Memoranda filed to document need for and use of contingencies
Performance status	Results of performance measurements
Verification of completion/ closure	Evaluation of performance measurement results in the context of the definitions of construction complete
Design of O&M and long-term care	"As builts," decision document specifications, operations manual

Appendix H: Relevant Environmental Restoration Courses and Policy References

Environmental restoration courses that complement this guidance include:

- Principles of Environmental Restoration I: Investigation and Response Selection - techniques for streamlining CERCLA and RCRA (HSWA) projects
- RCRA, Superfund & EPCRA Hotline Training Module - an introduction to the Superfund Response Process
- Remedial Design/Remedial Action Training- RD/RA Training Program for Superfund Remedial Project Managers (RPM)
- US DOE Project Management Training - a three-week course on how to manage DOE projects, including environmental restoration projects
- US DOE Remedial Investigation/Feasibility Study Course - an orientation to CERCLA and introduction to implementing the RI/FS process at DOE sites
- US DOE Risk Assessment Course - an introduction to human health and ecological risk assessment
- US DOE Subpart S Corrective Action Course - an introduction to the concepts and practices to follow when conducting RCRA corrective actions

Major policy references used in developing this guidance include:

- *EPA Strategy on RCRA Corrective Action: Advanced Notice of Proposed Rulemaking* (61 FR 19432), May 1, 1996
- *Expediting Cleanup Through Early Identification of Likely Response Actions*, DOE/EH-413-9902, May 1999
- *Expediting Cleanup Through Problem Identification and Definition*, DOE/EH-413-9904, May 1999
- *Expediting Cleanup Through Use of a Project Team Approach*, DOE/EH-413-9911, August 1997
- *Guidance for Evaluating the Technical Impracticability of Ground Water Restoration*, OSWER Directive 9234.2-24, October 4, 1993
- *Guidance for Scoping the Remedial Design*, EPA/540/R-95/025, 1995
- *Guidance on Expediting Remedial Design and Remedial Action*, EPA/540/G-90/006, 1990
- *Guide to Documenting Cost and Performance for Remediation Projects*, EPA/542/B-95/002, 1995
- *Managing the Corrective Action Program for Environmental Results: The RCRA Stabilization Effort*, October 25, 1991
- *Phased Response/Early Actions under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*, DOE/EH-0506, November 1995
- *Presumptive Remedies: Policies and Procedures*, EPA Directive 9355.0-47FS, September 1993
- *Proceedings: RCRA Corrective Action Stabilization Technologies*, EPA/625/R92/014
- *Procuring Innovative Technologies at Remedial Sites: Q's and A's and Case Studies*, EPA/543/F-92/012, 1992
- *Promotion of Innovative Technologies in Waste Management Programs*, OSWER Directive 9380.0-225

- *RCRA Corrective Action and CERCLA Remedial Action Reference Guide*, DOE/EH-0001, 1994
- *Remedial Design/Remedial Action Handbook*, EPA/540/R-95/059, 1995
- *Remedial Investigation/Feasibility Study (RI/RS) Process, Elements, and Techniques Guidance*, DOE/EH 94007658, December, 1993
- *Remediation Technologies Screening Matrix and Reference Guide,* Second Edition, EPA/542/B-94/013, 1994
- *Rules of Thumb for Superfund Remedy Selection*, EPA 540-R-97-013, August 1997
- *SAFER: Remedial Investigation/Feasibility Study (RI/FS) Guidance, Modules* DOE/EH-9400765
- *Stabilization Technologies for RCRA Corrective Action*, EPA/625/6-91/026, August 1991
- *Uncertainty Management: Expediting Cleanup Through Contingency Planning*, DOE/EH/(CERCLA)- 002, February 1997

Appendix I: Glossary of Terms And Acronyms

The following terms and acronyms have been throughout this guidance document. The definitions offered here reflect the intended meaning for these terms as used in this text.

Allowances - Areas of flexibility within decision document language which allows different approaches or designs to be developed to satisfy a need in the design package. In general, a requirement is defined broadly so that the designer is not overly constrained in how the objective is met.

As-Builts - Drawings and descriptions of facilities and/or structures which accurately depict how the facility/structure was built. These materials are intended to capture changes that may have been made during construction and, therefore, would not be reflected in the design package.

CERCLA - See Comprehensive Environmental Restoration, Compensation, and Liability Act

Closure - Completion of all environmental response activities such that a site is declared uncontaminated and, when relevant, removed from the National Priority List (NPL). Closure differs from completion as the term is used here, in that completion refers to the point at which all construction activity is concluded. Completion and closure may occur at the same time if a response removes all contamination as a result of the construction activity. If there are post-construction activities (e.g. operation, monitoring, deed restrictions), closure has not been reached when construction is complete.

Closure Report - Means of documenting the actions taken to reduce risk at a site to acceptable levels without the requirement for any further long-term care. This document usually coincides with removal of a site from the National Priority List and includes information on the response taken and the results of all verification monitoring.

Competitive Procurement - A means of obtaining materials or services through solicitation of bids from at least three sources with the selection based on price and/or technical criteria on the basis of which the bidders compete.

Completion - Conclusion of the construction activities related to implementation of an environmental response at a site. (See Closure.)

Completion Report - Means of documenting the actions taken to complete construction at a site**.** Typically contains a statement of the problem that was addressed, a description of the technology employed to resolve the problem, as-builts, results of all monitoring activities conducted during construction, and verification that the objective of construction work was met.

Comprehensive Environmental Restoration, Compensation, And Liability Act (CERCLA) - PL 96-510, also known as Superfund, is the enabling legislation passed in 1980 under which funds are made available and mechanisms are put in place to restore inactive properties that are found to have contamination at levels that pose unacceptable risks to human health or the environment.

CERCLA was broadened through passage of the Superfund Amendments And Reauthorization Act (SARA) of 1986.

Consensus - Agreement on the part of all parties to a decision as to the course of action. In the context of core team decisions for environmental response, indicates that no single voting party is so opposed to the resolution that they will not stand behind the decision. Individual parties may not believe a decision is the best possible decision, but they must believe it is an acceptable decision.

Containment - Response actions with the objective of stopping further migration of contaminants in the environment. Example technologies include capping, hydraulic barriers, and liners.

Contingency - Action or plan of action designed to counteract the impact of conditions observed during implementation to deviate from those assumed as the basis for designing a response. Contingency responses become the primary response when monitoring indicates that conditions prevail which will prevent the designed response from meeting its objective. Contingencies are employed as a safety net so that implementation can proceed without having to characterize all site conditions to the point where they are known with certainty.

Core Team - Group of co-project managers representing the decision making bodies for a site. Groups represented are those that have the power to say no to proposed actions. Generally speaking, the core team is comprised of the project managers from the Department of Energy, the Environmental Protection Agency, and the state regulatory authority overseeing the environmental restoration program. The core team works together to plan, oversee, and interpret technical aspects of a project. Decisions and enforcement remain the sole province of the authorized regulatory body.

Cost Plus- Contracts structured to compensate the contractor by paying the cost of services rendered plus an agreed upon percentage or fixed fee.

Decision Document- Instrument used to document the decision made as to how an environmental response problem is to be resolved. Under CERCLA, the document is a Record of Decision (ROD). Under RCRA, the document is the statement of basis. In both cases, the document states the nature and extent of the problem being addressed, the objective of the response selected, the alternatives considered in the selection process, and requirements imposed on implementation of the response.

Decision Rule - A concept used to document what constitutes sufficient information to make a decision. The rule is structured as an IF, THEN statement with the IF portion setting the conditions which if encountered will result in the action prescribed in the THEN portion.

Design - The activity undertaken to translate the requirements and objective provided in a decision document into a set of instructions sufficiently detailed to enable a contractor to implement the selected response and meet the objective. In a broader context, design includes all activities associated with development of the design package including identification of options during the scoping phase. However, for the purposes of this guidance, design is often referred to detailed design, the quantitative translation of concepts into plans and specifications.

Design Package - Drawings, plans, specifications and related instructions required to enable the implementation contractor(s) to install the response properly.

Design Basis - Quantitative and qualitative description of the conditions, assumptions and performance specifications upon which a design is based.

Deviation - Condition or parameter which when encountered during implementation is found to differ from the design basis to the degree that it may be necessary to invoke a contingency to ensure meeting restoration objectives. Deviations arise because of an earlier decision to manage an uncertainty by preparing a contingency rather than conducting further investigations until the condition/parameter is characterized with certainty.

Deviation monitoring - Procedures employed to observe site conditions or parameters whose values are sufficiently uncertain that when encountered during implementation of a response may dictate use of a contingency to ensure restoration objectives are met. This form of monitoring is predicated on the belief that the condition being monitored could have a value so different from that assumed during design that it will impact our ability to restore the site. Results of monitoring are reviewed to determine if a threshold is crossed indicating that the contingency is required.

Dig Face - Side walls of an excavation.

Early Completion Bonus - Lump sum or per day fee offered to induce completion of work ahead of schedule. Bonuses are usually offered as a counterpoint to liquidated damages.

Environmental Response - Set of activities performed to ensure that a site is restored to a state that does not pose unacceptable risks to human health or the environment. Environmental **response** may be conducted voluntarily or in response to programs initiated under RCRA (corrective measures), CERCLA (remedial actions), or analogous state programs.

EPA - U.S. Environmental Protection Agency.

Fatal Flaw - Condition or parameter value which impacts the implementability or efficacy of a response to the degree that the response will not meet the objective or is no longer the preferred option. A condition or parameter value that can be accommodated through extensive modification is considered a fatal flaw if the cost or impact of the modification are such that there is a more desirable response action that should be considered first.

Federal Facility Agreement (FFA) - Instrument required under DOE Order 5400.4 to establish the schedule and framework within which environmental response will be conducted at DOE sites. The term is often used interchangeably with Interagency Agreement. Agreements are negotiated between EPA and DOE and, in some cases, the host state.

FFA - See Federal Facility Agreement.

Fixed Price - Contracts under which the client agrees to pay a fixed sum for delivery of a prescribed scope of work by the contractor regardless of the cost incurred to complete the scope.

Fixed Unit Price - Contracts under which the client agrees to pay a fixed sum per unit of work performed. Hence the total contract award is calculated as the product of the fixed unit rate and the number of units required.

Hierarchy Of Probable Technologies - A list of the technologies most likely selected for a response at a site ordered on the basis of most desirable first. The hierarchy is used to focus data collection efforts on parameters needed to evaluate the most likely response actions and to identify early in the process the alternatives that should be evaluated if the preferred technology is found to have a fatal flaw.

Implementability - Aspect of a response that characterizes the ease with which it can be installed and made functional. Contributing factors include availability of essential resources, access and spatial requirements, sensitivity to uncontrollable variables, and logistics.

Implementation - Activities associated with installation of a design through completion. Implementation generally encompasses construction, shakedown and startup. It does not include routine operation or long-term care.

Incentivization - Use of monetary inducements to encourage contractors to reduce time and cost of design and implementation activities e.g. liquidated damages, avoided cost sharing and award fees.

Key Design Parameter - A characteristic of a site or technology the value for which will materially affect the design, cost and effectiveness of a response. Key design parameters are such that significantchanges in value may render a technology unsuitable for a site or at least less desirable than an alternate. In the extreme, a key design parameter with an adverse value would be a fatal flaw.

Liquidated Damages - Penalty imposed as a deduction for failure to complete work on schedule. Liquidated damages are most often incorporated in contracts where there are major costs or damages associated with failure to meet the schedule e.g. product is associated with Federal Facilities Agreement milestone for which stipulated penalties may be imposed.

Long-Term Care - Activities required after completion of construction in order to maintain conditions that are protective of human health and the environment. Long-term care may include operation of response facilities e.g. treatment plant for extracted ground water, monitoring, and maintenance of containment and access barriers.

Long-Term Monitoring - Activity performed after completion of construction as a means of determining if a response is meeting the restoration objective. Long-term monitoring is associated with responses that do not result in closure upon completion of construction. The intent of the monitoring is to verify that the response is working as designed, or alternately provide an advance warning that the response was not successful.

Monitored Natural Attenuation - Response action that relies on the presence of natural chemical, hydrogeological, and biological conditions to degrade, denature and/or immobilize contaminants so that they do not comprise an unacceptable risk to human health or the environment. Key active elements of the approach are use of monitoring to verify that attenuation is proceeding as predicted and availability of contingencies to mitigate any risks that may arise due to insufficient attenuation.

National Contingency Plan (NCP) - Framework that sets certain minimum requirements for actions to be recoverable under CERCLA. The National Contingency Plan has subsequently become the template for all environmental response programs.

NCP - See National Contingency Plan.

Performance Measurement - Means of monitoring progress during the implementation of response actions and subsequent operation.

Plug-In Approach - Method of selecting a response wherein sets of qualifying conditions are specified and matched with corresponding technologies that would be best suited for those conditions. The plug-in approach is applied at facilities where there are numerous waste management units or release sites with virtually identical characteristics which lend themselves to development of generic responses.

Post-Construction - Period after completion of construction implementation activities.

Pre-Decision Document Phase - Time period prior to issuance of the decision document. Pre-decision activities include scoping of the problem, site characterization, alternative evaluation, and treatability studies.

Pre-Mobilization - Design and staging of required resources for a contingency prior to encountering the deviation that would necessitate implementation of the response.

Presumptive Remedy - Response found to be the preferred action for a given set of circumstances so often that its selection is presumed whenever those conditions prevail. Presumptive remedies are identified by the EPA in guidance documents which prescribe how and when they can be used.

Principles Of Environmental Restoration - A set of four underlying concepts that have been identified as key to streamlining environmental response efforts. The principles in the order presented in this guidance are:

- Principle One - Define objective and maintain focus on it
- Principle Two - Identify the probable means of achieving the objective early
- Principle Three - Manage uncertainties through reduction and contingencies
- Principle Four - Employ early, open communication and consensual decision making

Problem Statement - Clear, concise statement of a site condition posing a real or potential unacceptable risk, or a condition that the core team determines requires a response. The problem is the essence of why environmental response is necessary at a site and, therefore, relates to chemical contamination above thresholds of concern. The problem statement is derived to provide a simple focus for restoration activities.

Project Delivery Strategy - Plan for how goods and services will be provided to accomplish the project objectives. The strategy typically addresses what will be performed in house, what will be contracted, how contracting will be conducted, and what type of contract vehicle will be employed.

RCRA - See Resource Conservation And Recovery Act.

Regulator - Federal, state or local official with the authority to enforce the Federal Facility Agreement or other programs affecting environmental response activities. For DOE sites, the federal and state officials are the primary regulators in a decision making role.

Regulatory Community - Officials with status as a regulator with regards to environmental response at a site.

Requirements - Elements of a decision document which constrain the design and implementation activities by defining what must be included and what can not be included in the response. Specific areas incorporated in requirements include the problem being addressed, the objective of the restoration effort, the nature of the response, the definition of an acceptable end state, and other applicable or relevant and appropriate requirements. The latter category refers to items arising from the need to comply with other related federal, state, and/or local regulations.

Residual Uncertainty - Conditions or parameters not sufficiently characterized through investigation to be able to affirm their state or value with certainty. A conscious decision has been made to manage these uncertainties through contingencies on the basis of lower projected costs or inability to reduce them through further investigation.

Response Selection - The decision with regard to what technology to apply in order to accomplish environmental response objectives. This decision is formalized with issuance of the decision document.

Resource Conservation And Recovery Act (RCRA) - PL 98-616, the enabling legislation passed in 1976 and amended by the Hazardous and Solid Waste Amendments in 1984 under which the generation, transportation, storage, treatment, and disposal of hazardous wastes are regulated. The corrective action segment of the regulatory program provides the framework for EPA and states to require restoration of contaminated sites as a condition for obtaining permits to continue hazardous waste-related activities. The corrective action program for restoration of active sites is the analog for the CERCLA remedial action program for inactive sites.

Response - The specific action or actions taken to resolve the condition creating a contamination problem at a site. In the RCRA program, the response may be a removal, stabilization or corrective action. In the CERCLA program, a response may be a removal or a remedial action.

SACM - See Superfund Accelerated Cleanup Model.

SAFER - See Streamlined Approach For Environmental Restoration.

Sole Source - A procurement offered to a single supplier on the basis that the supplier is so uniquely qualified to provide the goods or services that there is nothing to be gained from attempting a competitive procurement or that a competitive procurement would delay time critical activities. Grounds for sole source justification may include access to proprietary technology or information; unique skills, knowledge or experience that would be difficult or impossible to duplicate; or ability to mobilize more quickly for time sensitive activities.

Stakeholder - Individual or organization that is or will be impacted directly by site contamination or the restoration effort. At DOE sites, stakeholders include the DOE, state and federal regulators, Indian Nations, the local community, the public in general, and special interest groups such as environmental organizations and recreationalists.

Stewardship - Term used to encompass post-construction activities such as operation and maintenance, long-term care, access restrictions, and long-term monitoring. In essence, stewardship is required for any site for which the response involves activities during an extended period between completion and closure, implying that a steward is needed to ensure that activities are conducted when required and in the required manner.

Streamlined Approach For Environmental Restoration (SAFER) - Approach to accelerating environmental response through application of data quality objectives and the observational approach as a means of focusing efforts to conserve resources.

Streamlining - Generic term for the organization of environmental response efforts in a manner that reduces cost and schedule from the baseline process oriented approach that has historically been applied. Streamlining is an attempt to move quickly to the essential decisions in the restoration program by eliminating unnecessary data collection, redundant activities, and unproductive confrontations between stakeholders.

Superfund Accelerated Cleanup Model (SACM) - Approach to environmental response that utilizes removal authority and early actions to promote material progress as quickly as possible, as well as, consolidating site assessment activities and response selection. SACM encourages use of presumptive remedies and related guidance to take advantage of experience gained from application of restoration programs over the years at sites with common characteristics.

Technology - General approach to a response action encompassing use of a particular chemical or physical phenomenon capable of meeting project objectives. Technologies are not specific to a unique design, but are specific to the underlying principles that make the technology effective for its intended purpose. Biological treatment would be a technology. Within that technology, there would be numerous unit process options such as activated sludge, trickling filter, and extended aeration. Example technologies often applied as responses at DOE sites include:

Removal Technologies
- Excavation
- Extraction wells
- In-Well Stripping
- Soil Flushing
- Soil Vapor Extraction
- Solvent Flushing

Treatment (In-Situ or Ex-Situ)
- Biological Treatment
- Physical-Chemical Treatment
- Soil Washing
- Stabilization/Solidification
- Thermal Destruction

Containment
- Barrier Walls
- Capping
- Permeable Treatment Barriers

Technologies can be defined more narrowly by indicating a subset of unit process options such as membrane separation technologies or in-situ bioremediation technologies.

Threshold - Specific value which divides the range of all possible values for a key design parameter into two subranges, such that presence in one subrange would change a decision on response selection or design when compared to presence in the other subrange. Thresholds are used in uncertainty management during design and implementation to indicate when a contingency is needed to counteract the potential impacts of encountering a deviation.

Uncertainty - Parameter or condition for which a discrete value or state can not be determined with certainty and the range of possible values or states is sufficiently large to have a significant impact on the selection and efficacy of a design.

Uncertainty Management - Approach to accommodating the reality that uncertainty is inherent in environmental response. Management is performed by balancing two alternative courses of action:

1) Reducing uncertainty by further characterizing the parameter or condition to narrow the range of possible values/states; and

2) Developing contingencies that counteract the impact of encountering values/states that cross a threshold value for the parameter/condition.

Uncertainty Matrix - A tool used to organize and facilitate consideration of uncertainty and its impacts on decisions. During pre-decision document activities, the uncertainty matrix is employed to assist in planning investigations and evaluating the effects of uncertainty on response selection. After issuance of a decision document, a design uncertainty matrix is used to assist in evaluating the effect of residual uncertainty on the design basis.

Uncertainty Reduction - Collection of information to narrow the range of possible values for an uncertain parameter or condition. If uncertainty is not reduced to a range that does not span a threshold value, contingencies are needed to manage the residual uncertainty.